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Review Article

ENHANCEMENT OF POWER QUALITY IN A GRID CONNECTED UDE BASED PV INVERTER

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Abstract
The LCL filter is commonly used as a grid-to-grid interface. Nonetheless, due to the features of LCL filter and process uncertainties, designing a controller with proper parameters is complex. In this paper, with the LCCL filter, the order of the inverter control system can be reduced to first order from third order and a strategy for controlling the inverter connected to the grid based on uncertainty and disturbance estimator is proposed with LCCL filter. The main objective of this paper is to upgrade the efficiency of grid-connected PV inverters with proposed LCL filter.

Keywords: social and legal competence, structure, future engineer, professional competence.

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INTRODUCTION

As it is necessary in generation system, grid-tied plays a vital role to secure high-quality power into the power grid. To reduce the high frequency current harmonics caused by PWM , LCL filter is used.

By checking the similarities with L filter, LCL filter has the greater ability to suppress the high frequency harmonics. Moreover, LCL filter is a third-order resonance peak device involving a more sophisticated grid current regulator to preserve system. [4][11-16].

Shen et al. Proposed LCCL filter, which is an interesting topology of the LCL filter. In this topology, by dividing the LCL filter capacitor into two parts and selecting reasonable LCCL parameters, the order of the filter (controllable part) can be downgraded to first order from first order. The inverter controller with LCCL filter is easy to design and the filter has the ability to suppress HFH. Although the monitored variable has passed from the inserted gate current to the current of the separation capacitor, the resonance peak still occurs in the LCCL filter [17-20]. There are many methods available to suppress the LCCL resonance peak [1]. And the regulation of the applied mains current can be obtained by regulating the current of the separation capacitor when the LCCL The resonance overvoltage suppression system is correctly configured. There are many methods for controlling the current of the injected network, [1] [6] The RC and PR controls will add an infinite gain at any defined frequency centered on internal mode theory to eliminate the stationary state error, but the robustness of the controller is still a piece.

Relatively speaking, due to its simple structure and easy to implement, PI control is widely used in industrial applications, although it cannot achieve infinite gain. An effective approach to compensate for the loss of PI control and minimize the impact of line voltage is the supply of line voltage. In fact, collecting controller parameters is also a problem in the design of the PI system. The rectifier output will have many harmonics and will reduce the harmonics and make the output stable so that the circuit can perform its operations better and the filter can do it. The rectifier output will enterfilter where the harmonics will be reduced, and the filtered output enters the grid or load to which the supply is given. The filter circuit is a combination of capacitors, inductors and resistors[26]-[30]. If we require the dc output inductors are used which has the property to allow the dc component and block the ac components[6]. If we require the ac component as output capacitor is used as it alloys the ac component and dc components are not passed through the capacitor.

In the past decades, a variety of methods have been developed for device fluctuations and disruptions, including adaptive management, sliding mode control, and [1] uncertainty and disturbance estimator (UDE)-based control. Between UDE-based control is more important in linear systems due to its strong tracking efficiency, complexity and disturbance rejection capability. Between them, the UDE-based control has become a research hotspot due to its strong tracking efficiency, instability and destructive rejection capabilities in linear systems.

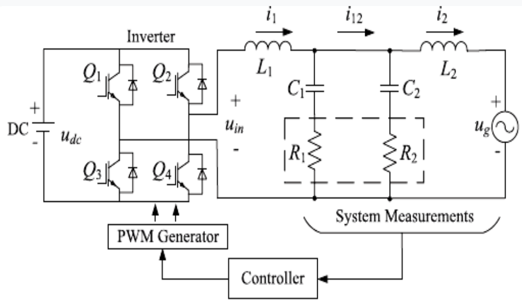


Fig 1: **System Topology of Grid − tied**

The cost of the UDE-based controller would increase compared to the PI controller, as it requires additional sensors. The state vector for the PI controller and the UDE-based controller is the same in this article, depending on the LCCL filter. Therefore, it is possible to develop the UDE-based controller for the LCCL type inverter [7][20-25]. In this article, a control strategy of the inverter connected to the network with a LCCL filter centered UCC, whose topology of the inverter is identical to that of [3], is introduced, except that a category of resistance of passive amortization is included. The specification of the controller based on UDE is transformed into the configuration of the parameters α, β and k according to the characteristics of the inverter. Unlike the conventional PI controller, the parameters of the PI UDE controller are defined by the parameters of the reference model and by the low-pass filter. Taking into account the analysis of the sampling calculation and the PWM delays of the half-sampling, the precision is illustrated, the range of the adjustment button of the controller is clear. A simple and clear tuning algorithm is provided for engineering applications. An advanced approach based on LCCL is suggested to improve the impact of grid voltage. In extension, the photovoltaic inverter is used as a source [2]. This takes into account the impact of delays in the voltage of the direct supply network. The effect of delays in the feedforward system is marginal. Finally, the adjustment and comparison tests are carried out on a 2 kW inverter. Most of this document is structured as shown below. The configuration of the device and the characteristics of the LCCL with passive damping resistance are illustrated in section II. The UDE-based current controller is designed in Section III, and a design process for the UDE-based current control parameters is studied. A UPS line voltage supply system with LCCL is suggested to eliminate the induced current distortion in the grid that occurs from Harmonics line voltage. Experiences and comments are provided in Section IV to validate the effectiveness of the proposed system. Finally, the argument is presented in Section V of this document.[1]

MODELLING OF LCCL FILTER

Moderately, PI control is broadly utilized in mechanical applications on account of its straightforward structure and ease to actualize, although it can't accomplish infinite gain. A successful way to deal with remunerate the PI control execution and lessen the impact of the matrix voltage is network voltage feedforward. Besides, the determination of controller parameters is additionally an issue in the plan of PI control. An advantageous and express controller structure strategy for PI control. In view of a precise framework model and unsettling influence data, the controller parameters can be effectively chosen. In an case, difficult to acquire exact inverter and disturbance models. For instant, the order of LCCL filter cannot be debased to first request accurately because of parameter vulnerabilities. Therefore, it is important to study the effect of uncertainties and unsettling influences are essential.

As Fig. 1 indicates the topology of the LCCL filter system with an inverter connected to the single-phase network[3] composed of an inductor The inverter side, an inductance Lb on the grid side, a capacitor Ca on the inverter side and Cb on the grid side. Ra and Rb are a group of damping resistance in the discontinuous image. The control strategy suggested for LCCL is an indirect control method, which differs from the traditional current control scheme, where the regulated current is iab instead of ib

Appling KVL, KCL equations to the loops in Fig 1

$$v_{in} = L_1 i_1 s + \frac{1}{c_1 s}(i_1 - i_{12}) \quad (1)$$

$$\frac{1}{c_2 s}(i_{12} - i_2) + \frac{1}{c_1 s}(i_{12} - i_1) = 0 \quad (2)$$

$$L_2 s i_2 + \frac{1}{c_2 s}(i_2 - i_{12}) = 0 \quad (3)$$

From (3),

$$i_2 = \frac{i_{12}}{L_2 C_2 S^2 + 1} \quad (4)$$

From (2),

After solving,

$$\frac{i_{12}}{v_{in}} = \frac{\gamma(1-\gamma)s^2 LC + 1}{\gamma L^2 S^3 - \gamma^3 L^2 S^3 + LS} \quad (5)$$

$$\frac{i_{12}}{v_{in}} = \frac{\gamma(1-\gamma)S^2 LC + 1}{\gamma(1-\gamma)L^2 CS^3 + LS} \quad (6)$$

$$\frac{i_{12}}{v_{in}} = \frac{1}{LS} \quad (7)$$

The effect is the same as for a single L filter. The injected grid current control device can be easily configured. And 1/Ls is the open loop within the inverter system's controllable portion[10].

It is easy to calculate and express the uncontrolled part of the system from i12 to i2 as follows:

$$\frac{i_2}{i_{12}} = \frac{1}{C_2 L_2 S^2 + 1} \quad (8)$$

When R1 and R2 is considered,

$$\frac{i_2}{i_{12}} = \frac{1 + R_2 C_2 S}{C_2 L_2 S^2 + R_2 C_2 S + 1} \quad (9)$$

It is easy to design for first order system but always not possible because of system parameters. So, UDE controller with LCCL filter is Proposed.

UDE CURRENT CONTROLLR

The UDE [8] (Uncertainty and Disturbance estimator) is used to identify and deal with the problems in the system and this estimator also helps in industrial purposes where if we don't know the reason for the delays that occur, and these delays can also be termed as additional disturbances. Not only the disturbances occur in the system this type of estimator also identifies the external disturbances by which the system will be affected. For improving the efficiency and to increase the stability these estimators cannot identify the disturbances directly. For identifying the disturbance first, we must know the disturbance occurs from the measuring variables and have to compensate the disturbance for better system performance. The filter used is the most important for this type of estimators which are generally low pass filters and UDE is a combination of several components like Filter, Controllers [9] and many other because of which the economic cost of the system will slightly increase.

From equation 7,

$$V_{in} = Ls\, i_{12} \quad (10)$$

$$V_{in} = L.\frac{di_{12(t)}}{dt} \quad (11)$$

When PWM inverter is at unity gain,

$$x(t) = ax(t) + bu(t) + fx(t)d(t) \quad (12)$$

For inverter with LCCL filter

$$x_m(t) = a_m x_m(\text{t}) + b_m u_m(t) \quad (13)$$

$$\text{Error e(t)} = x_m(t) - x(t) \quad (14)$$

$$\dot{e}(t) = (a_m + k)e(t) \quad (15)$$

$$\text{e(t)} = a_m x_m(t) + b_m u_m(t) - \text{bu(t)} - \text{fx(t)} - \text{d(t)} \quad (16)$$

By substituting equation [16] in equation[15]

$$a_m x_m(t) + b_m u_m(t) - bu(t) - fx(t) - d(t) = (a_m + k)e(t) \quad (17)$$

$$u(t) = b^{-1}[a_m x_m(t) + b_m u_m(t) - fx(t) - d(t) - ke(t)] \quad (18)$$

$$fx(t) + d(t) = u_d(t) \quad (19)$$

from equation (12),

$$u_d(t) = \dot{x}(t) - bu(t) \quad (20)$$

Above equation indicates the uncertainty and disturbance of a system.

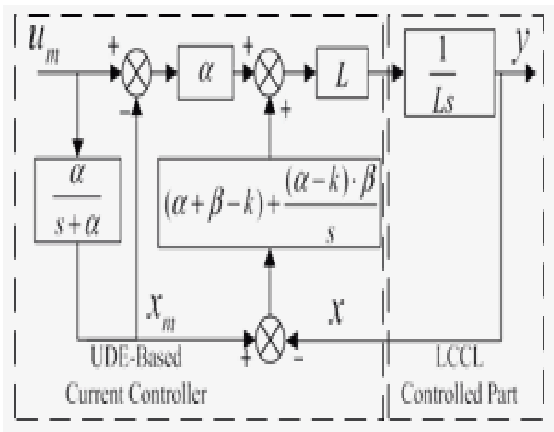
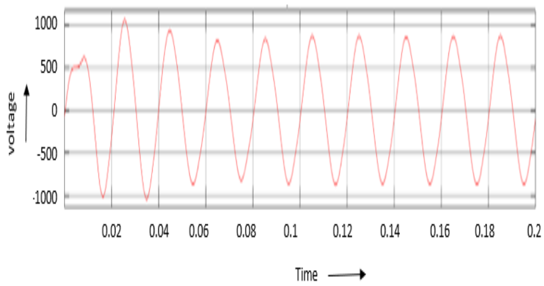


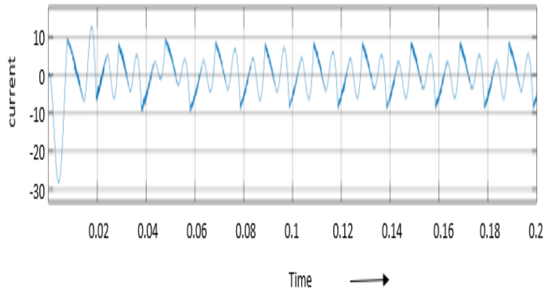
Fig 2: Block diagram of UDE Controller

Table 1: System parameters

Parameters	***Values***
DC bus voltage V_{dc}	380V
Voltage V_g	220V
Period T_s	100µs
Frequency f_c	10KHz
Inductance of Inverter side L_1	3.8mH
Inductance of Grid side L_2	2.5mH
Capacitance of Inverter side C_1	4µF
Capacitance of Grid Side C_2	6µF
Resistance of Inverter side R_1	12Ω
Resistance of Grid side R_2	8Ω

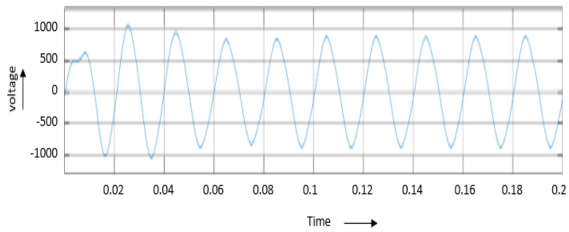


(a)

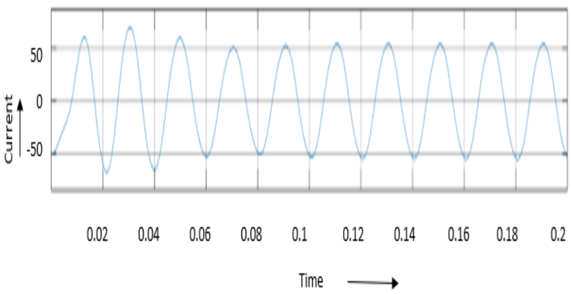


(b)

Fig 3: Results of UDE-based Controller before the Filter (a) Voltage at inverter side (b) Current at inverter side.



(a)



(b)

Fig 4: Results of UDE-based controller after Filter (a) Voltage at Grid side (b) Current at Grid Side

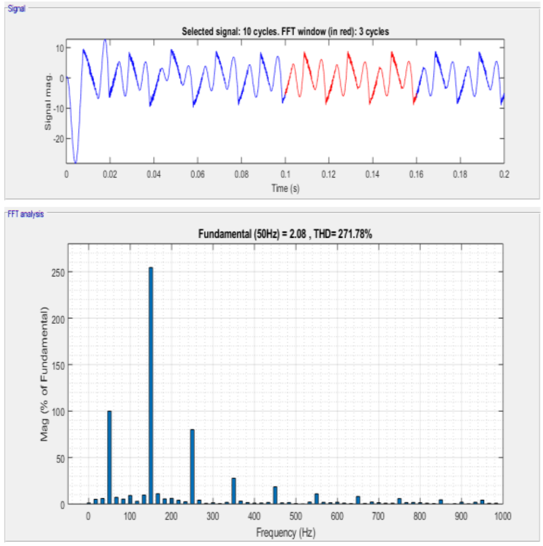


Fig 5: Result of THD of UDE controller before filter.

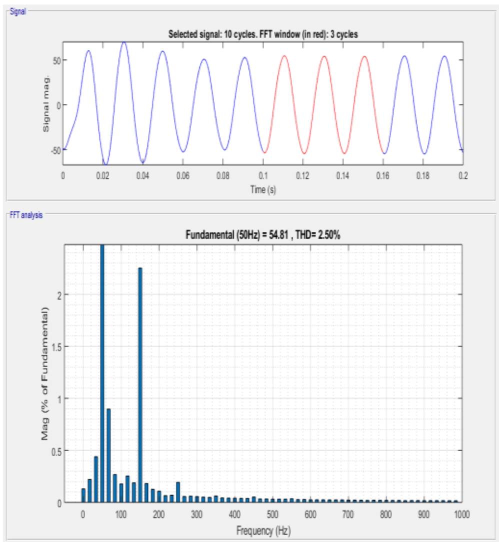


Fig 6: Result of THD of UDE controller after filter.

CONCLUSIONS

This paper only deals with 1-phase and the voltage and currents are illustrated. The total harmonic distortion is also carried out. The main aim of this paper is to upgrade the efficiency of grid-connected PV inverter with proposed LCCL filter. As an extension it is possible analyze the 1-phase full bridge inverter using LCCL filter mathematically and verify the outputs with the published results and then proceed the same methods with 3-phase and check for the reduction of harmonics.

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