Linear Active Disturbance Rejection Control based on Finite Impulse Response filter for harmonic control in microgrid

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Abstract: Island for micro grid is vulnerable at the run time, which is caused by the problem of load fluctuation, voltage frequency deviation, and distributed power supply power. These issues are generated by the uncertainty of three-phase voltage waveform output at the same time. All of these problems are urgently needed to solve, this paper designs a linear active disturbance rejection control to do robust estimation. This controller is based on optimal finite impulse response (FIR) filter, which is also combined with the immunity of the micro grid system harmonic method. The proposed controller is simulated. And it is compared with the classical PI controller and the linear active disturbance rejection controller respectively too. The simulation results show that the performance and robustness of the proposed model are better than those of traditional algorithm in microgrids.

1. INTRODUCTION

With the continuous progress and development of China's new energy science and technology, while the improvement of people's awareness of environmental protection, the microgrid based on new energy has been widely applied and promoted. As an important link of new energy connection load, inverter is also an important topic in the research of new energy power generation technology [1].

In the important historical process of rapid transformation from China's traditional intelligent distribution network to modern intelligent distribution network, and then to modern intelligent distribution network, micro-grid will play an important role in promoting the continuous progress and development of China's intelligent distribution network. The microgrid management system is mainly a small, medium-scale and large-scale power generation and distribution grid system that generally refers to a collection of various distributed on-grid power sources, energy storage power generation equipment, loads and other grid data systems. The autonomous power grid system can be connected to the grid internally and operate independently at the same time. It is a provincial autonomous power grid system that can completely independently realize the functions of self-operation control and management service. The extensive existence of microgrid not only changed the basic network operation structure, but also system structure of China's traditional large power transmission and distribution network. The continuous updating of network topology and structure will have a great
direct impact on the development of China's traditional large power transmission and distribution network.

From a macro overall research perspective, microgrid integrates the distributed micropower supply, load, energy consumption storage devices and other technologies, and forms an overall control of micropower network system through the connection, control of inverters, which provides customers with large capacity of active and reactive power. Not only can the grid-connected inverter of the public grid be connected to the grid-connected operation of the public grid, but also can be disconnected from the inverter in the public grid in the case of accidents or maintenance of the public grid[2].

Domestic and foreign scholars have carried out a lot of research on microgrid, it is constantly improved. In literature [3], the microgrid parallel multi-inverter is controlled, and its output power, output frequency will change with the change of active power and reactive load. So, the stable operation of the microgrid parallel multi-inverter is realized, and great progress has been made in the research on the stable operation control of the microgrid parallel multi-inverter. In literature [4], FIR filter and Kalman filter are used to design a method of robust estimation of harmonics in power system by using optimal finite impulse response (FIR) filter, which is applied to the state space representation of noisy current or voltage signals to estimate the amplitude of harmonic components. The main purpose of literature [5] is to combine the droop control and active disturbance rejection controller organically and closely in China's microgrid. By compensating disturbance in advance, the control effect is improved, at the same time, the simulation results show that it can effectively suppress the output error of the system.

2. MICROGRID MODEL BASED ON DROOP CONTROL

2.1 Droop control principle

The so-called low-power droop control, that is, droop control, also refers to the one-time low-power frequency modulation control principle of my country's traditional power system (such as wind turbines) to perform a variety of power electronic devices (such as inverters) and other equipment. A kind of low power control. In this low power control principle, the active and reactive power output by the inverter can be decoupled separately, it based on the relationship between active power and frequency, the low power based on the relationship between reactive power and voltage. The power droop characteristic is realized as a curve. Automatic regulation and control of inverter[6].

In Figure 1, the equivalent calculation of a microgrid power supply is transformed into a precise and simplified calculation model of a type containing a type of micropower, which supply to facilitate our analysis and design of the basic characteristics of various types of micropower sources, their power and signal transmission located within the microgrid.

![Simplified power characteristic model](image)

Fig. 1. Simplified power characteristic model

$Z$ and $\theta$ respectively represent the current amplitude ($Z = \sqrt{R^2 + X^2}$) and impedance Angle ($\theta = \arctan(X / R)$) of the equivalent voltage impedance of the input and output of the AC side of the bus of an inverter in a large microgrid, $V$ is the current amplitude of the equivalent voltage impedance of the input, output of the AC side of the bus and the grid side of an inverter; $E$ is the impedance amplitude of the equivalent AC voltage of the two inputs at the connection point of the bus of the public line. $\delta$ is the amplitude vector of the equivalent voltage impedance of two inputs and outputs on the AC side of the bus and the grid side of an inverter and the phase Angle difference of the equivalent
voltage impedance of two inputs and outputs at the connection between the AC power of the common bus and the bus.

According to the electrical theory, the output complex power of inverter AC side can be expressed as:

\[
S = P + jQ = V I = V \angle \delta \left[ \frac{V \angle \delta - E \angle 0}{Z \angle \theta} \right] = V e^{j \delta} \left[ \frac{V e^{j \theta} - E e^{j 0}}{Z e^{j \theta}} \right] = V e^{j \delta} \left[ \frac{V e^{j (\theta - \delta)} - E e^{j (-\theta)}}{Z} \right] = \frac{V^2}{Z} e^{j 0} - \frac{E V}{Z} e^{j (\theta + \delta)} = \frac{V^2}{Z} \cos(\theta + j \sin(\theta)) \frac{E V}{Z} (\cos(\theta + \delta) + j \sin(\theta + \delta))
\]

According to the formula, the active power and reactive power output on the AC side of the inverter are respectively:

\[
P = \frac{V^2}{Z} \cos \theta - \frac{E V}{Z} \cos(\theta + \delta)
\]

\[
Q = \frac{V^2}{Z} \sin \theta - \frac{E V}{Z} \sin(\theta + \delta)
\]

Due to impedance Angle \( \theta = \arctan(X/R) \), so \( \sin \theta = X/Z \), \( \cos \theta = R/Z \)

\[
P = \frac{V}{R^2 + X^2} \left[ R(V - E \cos \delta) +XE \sin \delta \right]
\]

\[
Q = \frac{V}{R^2 + X^2} \left[ X(V - E \cos \delta) +RE \sin \delta \right]
\]

In the general low frequency and high voltage AC transmission signal line, the AC impedance of the line is usually measurable and sensitive, is due to \( X \gg R \), so in the case of the value of R impedance can be fully automated to ignore, therefore, the current phase radian error between the vectors E and V that output high-frequency voltage downward at the AC side of the line and the vectors V and E that output the AC voltage upward on the side of the common line bus is very small, so in radians we're going to have approximately \( \sin \delta = \delta \), \( \cos \delta = 1 \), so this simplifies to:

\[
\delta = \frac{XP}{EV}
\]

\[
V - E = \frac{XQ}{V}
\]

According to the analysis of, the transmission of active power of inverter mainly depends on the power angle \( \delta \), the transmission of reactive power depends mainly on the voltage difference \( (U_1 - U_2) \). The mathematical equation of droop control is obtained:

\[
\begin{align*}
  f &= f^* - m(p - p^*) \\
  V &= V^* - n(Q - Q^*)
\end{align*}
\]

The droop control characteristics described can be described in the figure shown:
Given a reference output power threshold based droop when the function of an essential meaning of the control strategy can be as follows: the AC inverter of each load according to the reference output signal based on the reference input power threshold requirements for decoupling, then according to the load of each load droop angle movement characteristics curve, to each load based on the reference output power threshold requires a reasonable power distribution, the signal of each AC inverter control circuit and so will be automatically calculated to get its computations based on reference output parameter values, and then through the control circuit of the signal conversion control module, it is concluded that a computations based on reference output power requirement signal parameter values, then hang through each stage of the inverter load movement In order to achieve the uniform balance of the output power reference requirements of each load, the ac side board of each inverter can finally make the reference power requirement of the output power signal completely reach the rated power reference required to be set. As shown in the figure, FIG. 2(a) refers to the line determined by the m in the slope and the reference power $P_0$, the reference frequency $f_0$, while FIG. 2(b) refers to the line determined by the n in the slope and the reference power $Q_0$, the reference voltage $V_0$, with its slope m, n and reference points can be directly used to adjust the actual operating position of each distributed universal micropower supply by a new dynamic calculation method, determine how to correctly arrange each inverter according to the characteristics of various low vertical curve and the structure characteristics of the high plane curve after decoupling.

2.2 Dq transform

In the process of experiment, because the voltage mathematical model is analyzed in the time domain, it is time varying, which makes it particularly inconvenient to design the inverter control technology. Therefore, it is necessary to transform the three-phase stationary (A-B-C) coordinate system into the synchronous rotation of the grid fundamental frequency two-phase (D-Q) coordinate system by coordinate transformation. In this way, the fundamental wave sine variable in the three-phase A-B-C coordinate system is transformed into the dc component in the synchronous rotation D-Q coordinate system by coordinate transformation, and the design of the inverter controller can be realized [7].

Before the space of the two coordinate system transformation, according to the regulation, make this condition in three phase ac circuits, the two different (d or q) axis in the coordinate system of the two d and q axis space respectively and their corresponding active component and its reactive component, among them, for the dq axis rotation angular velocity, counterclockwise as the positive direction of rotation, q axis ahead of d axis 90 degrees.

From the equation of the phasor of the transformation matrix of the two coordinates, it can be analyzed that the three phase motion static (A-B-C) coordinate system is transformed into each other in order to obtain the transformation matrix of the two phase static rotation (D-Q) coordinate system $T_{3d/3s}$ can be expressed as:

$$T_{3d/3s} = \frac{2}{3} \begin{pmatrix} \cos(\omega t) & \cos(\omega t - 2\pi / 3) & \cos(\omega t + 2\pi / 3) \\ -\sin(\omega t) & -\sin(\omega t - 2\pi / 3) & -\sin(\omega t + 2\pi / 3) \\ 1/2 & 1/2 & 1/2 \end{pmatrix}$$

The inverse matrix of formula 10 is
Due to the main working principle of three-phase inverter is mainly three-phase ac circuit of three-phase input current evenly balanced and symmetrical each other, at the same time, based on the work of three-phase loop current balance can also be used for three-phase coordinate system before and after the transformation of the working principle of power conservation, shaft three-phase current conservation vector expression can be used to get two phase current of d-q vector of conservation of shaft current Can be expressed by formula 11 and 12.

\[ T^{-1}_y = \frac{2}{3} \begin{bmatrix} \cos(\omega t) & -\sin(\omega t) & 1 \\ \cos(\omega t - 2\pi/3) & -\sin(\omega t - 2\pi/3) & 1 \\ \cos(\omega t + 2\pi/3) & -\sin(\omega t + 2\pi/3) & 1 \end{bmatrix} \]  \hspace{1cm} (10)

Thus, the voltage and current vector equation of the three-phase inverter in the microgrid in the two-phase rotation (D-Q) coordinate system is expressed as formula 13.

\[ \begin{bmatrix} i_d \\ i_q \\ u_d \\ u_q \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \cos(\omega t) & \cos(\omega t - 2\pi/3) & \cos(\omega t + 2\pi/3) \\ -\sin(\omega t) & -\sin(\omega t - 2\pi/3) & -\sin(\omega t + 2\pi/3) \end{bmatrix} \]  \hspace{1cm} (11)

\[ \begin{bmatrix} u_d \\ u_q \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \cos(\omega t) & \cos(\omega t - 2\pi/3) & \cos(\omega t + 2\pi/3) \\ -\sin(\omega t) & -\sin(\omega t - 2\pi/3) & -\sin(\omega t + 2\pi/3) \end{bmatrix} \]  \hspace{1cm} (12)

2.3 Design of microgrid based on droop control

The control system structure of the isolated island microgrid designed in this paper is shown in figure 3. In order to effectively simplify the circuit model, the distributed load power supply model can be directly replaced by the DC load voltage source. The DC load power supply Udc can be connected to the three-phase AC load power supply R after the three-phase AC inverter and LC filter constitute a circuit. Output voltage value of the actual work of U0, current I0 after calculate the load power values of P, Q, droop control and park transformation to obtain the voltage reference Ud *, Uq *, the actual voltage value is obtained by extended state observer (ESO voltage measurements, the voltage reference by differential tracker TD do smoothness processing compared with voltage measurements, the error signal is used as the voltage signal of the inverter through the inner ring linear active disturbance rejection controller.
3. DESIGN OF CONTROLLER BASED ON ACTIVE DISTURBANCE REJECTION AND FIR FILTER

3.1 TD

In a general controller system, the error is obtained by the difference between the set value and the system input, which can cause the initial error to be very large, which can easily cause overshoot. In order to solve the problem of the speed and overshoot of the motor system, we reduce the initial error in the initial state. Since the initial output of the control system is generally zero, we arrange the transition process to the initial target value, which is what TD does. The discrete TD is shown in formula (14).

\[
\begin{align*}
    x_1(k+1) &= x_1(k) + h \cdot x_2(k) \\
    x_2(k+1) &= x_2(k) + h \cdot f_{han}(x_1(k) - x_d(k), x_2(k), r, h_0)
\end{align*}
\]  

(14)

In formula (14), \( h \) is the integral step, \( h_0 \) is a new variable independent of \( h \), it has a certain filtering effect on noise, \( k \) is the sampling time, \( x_1(k) \) is the transition process of the reference voltage, \( x_2(k) \) is the derivative of the transition process, \( f_{han}(x_1(k) - x_d(k), x_2(k), r, h0) \) is a nonlinear function, the expression is shown in formula (15).

\[
f_{han} = \begin{cases} 
    r \cdot \text{sign}(a), & |a| > d \\
    r \cdot \frac{a}{d}, & |a| \leq d
\end{cases}
\]  

(15)

In formula (15), \( r \) is the speed factor. Within the bearing capacity of the controlled object, the greater the value, the faster the speed of approaching the target value. The definition of \( a \) and \( d \) is shown in the following formula,
\[
\begin{align*}
    d &= r \cdot h_0 \\
    d_0 &= h_0 \cdot d \\
    y_0 &= x_i(k) - x_d(k) + h_0 \cdot x_i(k) \\
    a_0 &= \sqrt{d_z^2 + 8r \cdot |y_0|} \\
    a &= \begin{cases}
        x_i(k) + \frac{a_0 - d}{2} \cdot \text{sign}(y_0), & |y_0| > d_0 \\
        x_i(k) + \frac{y_0}{h_0}, & |y_0| \leq d_0
    \end{cases}
\end{align*}
\] (16)

3.2 ESO
Considering the inaccuracy of system modeling and the unpredictability of renewable energy output, an effective method is to treat system uncertainties as disturbances. If the sum effect of various disturbances can be estimated and their compensation is eliminated at the input end of the system, the system will be simplified as an integral series system [8]. The discrete ESO is shown in formula (17):

\[
\begin{align*}
    e &= z_i(k) - y(k) \\
    z_i(k+1) &= z_i(k) + h \cdot (z_i(k) - \beta_{01} \cdot e) \\
    z_i(k+1) &= z_i(k) + h \cdot (z_i(k) - \beta_{02} \cdot \text{fal}(e, 0.5, \delta)) + h \cdot u(k) \\
    z_i(k+1) &= z_i(k) - h \cdot \beta_{03} \cdot \text{fal}(e, 0.25, \delta)
\end{align*}
\] (17)

In formula (17), \(h\) is sampling period, \(k\) is the \(k\)th sampling time, \(b\) is observer gain, \(u\) is control output value, \(\beta_{01}, \beta_{02}, \beta_{03}\) are observer parameters, \(z_1, z_2, z_3\) are state variables, among them \(z_3\) is real-time estimation of internal uncertainties (such as parameter perturbations) and external disturbances of model objects, nonlinear \(\text{fal}\) function expression is shown as follows.

\[
\text{fal}(e, \alpha, \delta) = \begin{cases}
    e \cdot \delta^{\alpha-1}, & |e| \leq \delta \\
    e \cdot \left|e^{\alpha}\right| \cdot \text{sign}(e), & |e| > \delta
\end{cases}
\] (18)

In formula (18), \(\alpha\) is a constant between 0 and 1, \(\delta = j \cdot h\), where \(j\) is a positive integer, \(\text{fal}\) function is one essential meaning is to "big error, small gain" in quality control system engineering; small error, large gain "set mathematics for analog number fitting [9].

3.3 Design of FIR filter based on MATLAB
As at present in the mobile industry in the process of the information age of digital, intelligent, and push the "mobile network construction process, the digital filtering processing also gradually mature development has become a very widespread extremely important technical subject and professional research hotspot, and digital filtering processing technology is widely used in the application in the field of the major also one by one gradually has been more local attention and wide recognition. Compared with IIR type digital phase filter, FIR filter has made great progress in China with its very high phase linearity and phase frequency advantage. The hardware design of the digital signal filter can generally be realized directly by two simple control methods of direct control hardware or software. The main technical advantage of the latter is that the user can also directly change the digital filter to manual control through the hardware by adjusting the various parameters of the signal digital filter of signal processing performance of the whole, and for the MATLAB The need to provide all kinds of digital signal filter processing control toolbox is because it is a completely is a powerful digital signal processing function control function, it not only can not only directly corresponding used for control and automated design all kinds of digital signal filter, even big enough to directly make the software design staff can do the biggest worry, so it has become to FIR and other digital signal filter applications need to design a powerful control means.
3.3.1 FIR filter

FIR digital differential filter system is a nonlinear recursive function system, in which the impulse response function \( H(n) \) can be expressed as a finite length of function sequence, and the general expression form of each sequence function in the recursive system is:

\[
H(z) = \sum_{k=0}^{N-1} h(k)z^{-k}
\]

In the above equation, \( h(n) \) is a causal sequence, \( H(z) \) is a polynomial of degree N-1 of \( z_1 \), with poles of order N-1 only at \( Z = 0 \), no poles elsewhere, only any pole position of any N-1 zeros in a finite region \( Z \) plane. The basic structure of FIR system is direct type and cascade type. It has been widely used in the acquisition and processing of various radar transmitted signals, as correlator and radar reverser at the same time.

From the above equation, we can get an implementation framework structure of FIR filter in FPGA, as shown in figure 4, which mainly includes three parts: delay unit \( Z^{-1} \), multiplier and accumulator. This structure is a direct type of FIR filter structure, also known as the transverse structure.

![Fig. 4. FIR internal structure](image)

The design process of digital filter is:

1) According to the actual situation, the performance requirements of various filters are determined. Usually, this method is to put forward a performance requirement for a given digital filter in the signal frequency domain, which is generally the amplitude and phase response, namely its technical index.

2) In demand in the filter need to find a can satisfy the given default filtering performance requirements of very short time discrete filter of linear system, which is a very great stability of causal mathematical system using the method of functional group and fast approaching a preset performance requirements based on the requirement of the given filter, filter coefficient of the linear order to define the demand.

3) The system is implemented with finite precision. This includes a selection operation structure that quantifies the filter's coefficients, input variables, intermediate variables, and output variables to a fixed word length.

4) Through simulation, their frequency characteristics and phase characteristics are analyzed to verify whether the system we need to design meets the given performance.

3.3.2 FIR design based on filterDesigner

After setting the key indicators, enter the FDATOOL operation interface, and set the parameters of the designed filter in the interface: select Lowpass in the Filter Type; select FIR (Window) in Design Method; in Filter Order, select the specified order and select Kaiser window. In Frequency Specification, set the Frequency unit to Hz, and set the sampling Frequency to \( F_s=30.72 \) MHz, \( F_c=8 \) MHz. After setting the parameters, click the "Design Filter" button to obtain the amplitude-frequency characteristic curve as shown in the figure.
Fig. 5. FIR parameter setting

Using Matlab provided by the Simulink simulation tool box to achieve the characteristics and performance of the filter. Press the right mouse button in the Matlab command window and type Simulink to enter the simulation interface to create a new model workspace.

Fig. 6. Model interface to establish FIR Model
Two different simulation signal source jointly produced by the two analog signal filter frequency to
2 hz, 50 hz, respectively, in accordance with the design drawing 7 good even after two cables to filter
movement simulation, the circuit using oscillograph carries on the simulation test before filtering after
two basic structure and the waveform of the simulation signal source, after two of the same design
analog signal source with a filter. The basic structure of the waveform of the two analog signal sources
calculated after the simulation is shown in figure 8 below.

![FIR simulation model](image1)

**Fig. 7.** FIR simulation model

![Comparison of effect pictures before and after filtering](image2)

**Fig. 8.** Comparison of effect pictures before and after filtering

### 4. TIME DOMAIN SIMULATION RESULTS ANALYSIS

In this section, the isolated island microgrid model is built on the Matlab/Simulink simulation platform,
the performance of the designed controller based on active disturbance rejection and FIR is studied
when the load is switched off and the disturbance is added, then compared with the traditional PI
controller and LADRC. Among them, the simulation parameters of PI, LADRC are shown in Table 1
and Table 2 respectively, and the FIR parameters are described in 3.3. The voltage regulator input,
output filter load voltage on the DC side of the inverter is 800v, the AC output input filter load
 capacitor of the inverter is 1500 \( \mu \) F, the filtered load inductor is 0.6mh, the droop power coefficient \( m \)
is 1e-7 and \( n \) is 3e-4.

| parameters | value |
|------------|-------|
| \( kp \)   | 10    |
| \( ki \)   | 100   |

**TABLE I. PI CONTROLLER PARAMETERS**
TABLE II. LADRC CONTROLLER PARAMETERS

| parameter | value | parameter | value |
|-----------|-------|-----------|-------|
| $h$       | 0.01  | $\beta_{h2}$ | 50    |
| $h0$      | 1     | $\beta_{h3}$ | 100   |
| $r$       | 10    | $\alpha_1$  | 0.5   |
| $b$       | 19    | $\alpha_2$  | 0.25  |
| $\beta_{hl}$ | 150 | $\delta$    | 0.0025 |

TABLE III. FOPID CONTROLLER PARAMETERS

| parameter | value |
|-----------|-------|
| $K_p$     | 180   |
| $K_i$     | 3.6532|
| $K_d$     | 8.9811|
| $\lambda$| 0.3   |
| $\mu$    | 0.7   |

4.1 Comparison of switching load simulation

For the convenience of comparison, only two distributed power supplies are simulated, and the simulation time is 2s. One load is cut off at 0.3s, restored at 0.6s. Figure 9 and 10 are the comparison diagram of frequency, voltage changes during the operation of load switching and switching respectively. As can be seen from Figure 9, the FIR controller based on active disturbance rejection reduces the frequency to 50HZ with the minimum oscillation and the shortest time, while the accuracy of PI regulator is significantly worse than that of the combination of LADRC and FIR controller. However, under the condition of no interference, the FIR response based on active disturbance rejection is basically consistent with that of active disturbance rejection.

![Fig. 9. Frequency response of the three controllers to load changes](image-url)
4.2 Simulation and comparison of sudden interference

In order to simulate the instability of the output power of clean energy such as wind and solar power, random interference is added to the DC side of the inverter. As shown in Figure 11, sinusoidal signal with amplitude 1 and random signal interference with variance 50 were added at 1s.

Fig. 10. Voltage response of the three controllers to load changes

Fig. 11. Voltage waveform of the DC side-rush with interference
FIG. 12 and 13 show the response waveform comparison between frequency and voltage when sudden interference is added. It can be seen that the three controllers can ensure the frequency stability of isolated island microgrid, but PI is obviously affected by disturbance, the response waveform is very rough, and the frequency fluctuation becomes large. However, when using FIR combination, the frequency and voltage waveform change little, but the waveform appears a sudden spike when the disturbance amplitude is larger, indicating that the frequency and voltage are still affected by the disturbance. Based on the immunity of the FIR under the condition of disturbance can get very good control effect, the waveform is basic and same, in the absence of any disturbance in tends to steady state compared with PI controller and LADRC controller, the speed of response time is shorter, more responsive, adopt the immunity of FIR not only balance the LADRC smoother response, and of better on the response speed, excellent disturbance resistance. In the period from 0.3s to 0.6s, the responses of the three controllers are basically the same. Table 1 shows the frequency response indicators of the three controllers. As can be seen from FIG. 12, the FIR controller has the fastest response speed, and the voltage reaches a stable state at 6.023ms. On the basis of ensuring the reduction of overshot, the response speed performance is improved. The second is PI, the response time is 12.124ms, but the system stability is insufficient, while the response time of active disturbance rejection is 19.548ms. When one load is cut off at 0.3s, the three controllers can quickly reconverge, and the FIR is affected for the shortest time. Table 6 is the voltage response index of the three controllers. In general, the designed FIR controller based on active disturbance rejection has smoother response and shorter adjustment time when switching load.

![Frequency response of three controllers under perturbation](image)
Fig. 13. Voltage response of three controllers to disturbance

TABLE IV. THE FREQUENCY RESPONSE INDEX OF THE THREE CONTROLLERS UNDER THE DISTURBANCE OF THE NEEDLE TO THE CHANGE OF LOAD

| Time(s) | controller | Overshoot(%) | Setting time 2%(ms) |
|---------|------------|--------------|---------------------|
| t=2s    | FIR        | 4.755        | 5.008               |
|         | LADRC      | 4.875        | 5.015               |
|         | PI         | 11.135       | 19.968              |

TABLE V. THE VOLTAGE RESPONSE INDEX OF THE THREE CONTROLLERS TO THE LOAD CHANGE UNDER DISTURBANCE

| Time(s) | controller | Overshoot(%) | Setting time 2%(ms) |
|---------|------------|--------------|---------------------|
| t=2s    | FIR        | 0.170        | 6.023               |
|         | LADRC      | 0.357        | 19.548              |
|         | PI         | 25.949       | 12.124              |

5. CONCLUSION
This paper studies the secondary control strategy of microgrid based on droop control, and designs a control system based on active disturbance rejection and FIR filter to adjust the parameters of the controller. The various and possible problems are analyzed, which may need to be dealt with the actual applications in the microgrid. It also simulates and tests the load shedding and additional interference on the DC side of the inverter. So, it needs to design a controller based on noise immunity. It compares the controller based on FIR-based ADRC, the classic PI controller and LADRC controller. The results of the Matlab/Simulink simulation platform show that the designed controller can estimate the internal very well. It also shows that the external disturbances of the entire system has strong anti-interference
and performance. All of these can guarantee the performance of the microgrid effectively. The controller designed in this paper combines FIR and ADRC to solve the problem of three-phase voltage waveform distortion caused by the uncertainty of the output power of the distributed power supply. It has important practical significance for harmonic control and stable operation of microgrid. It can be adjusted quickly and accurately under interference conditions. The shortcoming of this research that the combination of ADRC and FIR filter has little difference when it only switches the power load. The next work is to do more research on this problem. I plan to improve the harmonic suppression effect and reliability of ADRC based on FIR.

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