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Retraction

Retracted: Research and Development of Digital Assembly Process System for Ultrasonic Transducers

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readerthat the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] X. Feng, X. Zhu, W. Zhao, and R. Shi, "Research and Development of Digital Assembly Process System for Ultrasonic Transducers," *Security and Communication Networks*, vol. 2022, Article ID 2507649, 7 pages, 2022.

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Research Article

Research and Development of Digital Assembly Process System for Ultrasonic Transducers

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In order to solve the problem of design efficiency of the digital assembly process, the author proposes a research using ultrasonic transducer technology. The main content of this research is to study the ultrasonic transducer elements according to the basic structure of the ultrasonic transducer.Through the study of equivalent circuit of ultrasonic transducer, the model of impedance matching design is constructed. Finally, the feasibility of ultrasonic transducer technology is obtained through experiments. Experimental results show that the transducer multichip structure of the ultrasonic transducer system and the LC matching network circuit can make the AOTF system achieve better results, and the diffraction efficiency is up to more than 70%, which is of great significance to the research and development of the current digital assembly process system. *Conclusion*. It is proven that the research of ultrasonic transducer technology can meet the needs of digital assembly process design efficiency.

1. Introduction

With the acceleration of my country's economic development and urbanization process, assembly is an important link in the entire life cycle of enterprise products and plays a very important role in the use of product costs and performance. With the development and progress of social science and technology, the processing and production of enterprises are gradually developing in the direction of lean. After the processing and production of the product are completed, the original assembly process management mode based on the assembly experience of the operator is no longer suitable for the current production needs [1]. When the assembly time occupies a long time in the production cycle of the product, the relevant personnel needs to think about how to shorten the assembly time of the product, and in this way, the application of digital assembly process management technology in enterprises is standardized, and the refined management of enterprises is realized while ensuring timely and accurate real-time management [2]. Improve the efficiency of assembly technology process design and improve the accuracy of process design. By establishing a worker-oriented operation card and standardizing the process of the operation card, the dependence on manual operation can be reduced, and the technical management efficiency of the assembly process can be improved while coordinating the application of technicians and equipment. The specific implementation method is as follows: in the 3D digital assembly environment, the corresponding process preparation operation is carried out in combination with the assembly BPM. Simplify the acquisition of relevant assembly process diagrams and patterns. Statistical operation of process regulations and reports realizes automatic operation management. Realize the effective integration of assembly process technology resources. The effective integration of the technical resources of the assembly process requires the adjustment of the work of the technical process personnel between the assembly plants, and the technical barriers between the workshops can be reduced through adjustment. The specific implementation methods of the effective integration of assembly process technology resources are as follows: first, the process personnel is required to log in to the system with a unique user name, accept corresponding work tasks in the system, and share management of digital resources in a unified environment [3]. Improve applicability and visibility of assembly process specifications. The assembly process operation process needs to be carried out for all workers, and during the operation, it is necessary to clarify the corresponding process, improve the operation quality, and reduce the dependence on human experience during operation. Improved applicability and visibility of assembly process specifications are achieved by formulating the corresponding operation card format and content requirements; demonstrating the operation through graphics, pictures, animations, and other intuitive methods; optimizing the content and form of the assembly process flow; and simplifying the operation process.

2. Literature Review

With the vigorous development of the country's current economy and the current background, in order to achieve efficient use of digital assembly process design, it is necessary to improve the current digital assembly process technology on the basis of domestic and foreign experience and to strengthen the management of the assembly site. The original assembly process specification is divided into two parts, one is a general process specification, and the other is a detailed assembly process operation guide [4]. The general process specification specifically includes process routes and catalogs and is generally used in the specified production planning and application of parts and resources of various scheduling departments. Refinement of the assembly process is a guide for assembly operations, including assembly process operation flow chart, precise process operation requirements, and assembly process resource management list. With the development of science and technology, the assembly process technology must realize electronic management, which provides important support for the subsequent paperless management of production. The electronic management of the assembly process needs to fully follow the electronic management characteristics, especially the electronic process specification operation and catalog information. Based on the current stage of assembly management, some paper management is required. Therefore, in order to ensure the feasibility of the assembly operation project, it is necessary to realize the combination of paper assembly management and electronic management. The development of digital assembly process management technology can greatly shorten the original product production cycle, simplify the existing assembly process procedures, save unnecessary resources and energy, and ensure the correctness and intuitiveness of the digital assembly process [5]. For this reason, enterprises need to pay more attention to digital assembly management when developing and effectively combining it with process technology, experimental technology, and modern management while studying digital assembly technology and transforming digital assembly process management technology in combination with actual development. In order to better apply the digital assembly process technology, it is necessary to speed up the training of relevant technical personnel during the specific operation, improve the relevant personnel's cognition of the digital assembly process management, and improve the social practicability of the digital assembly technology. In view of the above problems, the author proposes the research and development of the digital assembly process system for ultrasonic transducers [6]. The main content of this research is to construct a model designed by impedance matching based on the basic structure of the ultrasonic transducer, the study of the array elements of the ultrasonic transducer, and the study of the equivalent circuit of the ultrasonic transducer, and finally, the feasibility of ultrasonic transducer technology is obtained through experiments. The transducer multichip structure and LC matching network circuit of the ultrasonic transducer system can make the AOTF system achieve better results, and the diffraction efficiency can reach more than 70%, which is of great significance to the research and development of the current digital assembly process system.

3. Research Methods

3.1. Principle of Ultrasonic Transducer and Digital Assembly Process System

3.1.1. Basic Structure of Ultrasonic Transducer. High-frequency ultrasound is an important branch and research hotspot of ultrasound technology, compared with nondestructive testing and imaging technologies such as optics, radiography, and nuclear magnetic resonance, and its advantages are as follows: a. it can well balance the contradiction between high resolution and high penetration; b. it can characterize the mechanical properties of objects at the microscopic scale [7]. After nearly 20 to 30 years of development, high-frequency ultrasound has played an irreplaceable role in the evaluation and detection of electronic devices, the characterization of micromechanical properties of materials, and high-resolution biomedical imaging, cell imaging, and cell mechanical properties detection, as well as ultrasonic tweezers and other cutting-edge basic research and application technologies have shown broad prospects. Ultrasound transducer is the core device of ultrasound technology, and its characteristic parameters fundamentally determine the performance of the entire ultrasound system, but the development of ultrasound transducer has always been a technical bottleneck in ultrasound technology [8]. The main reasons are as follows: a. the ultrasonic transducer has a complex structure and cumbersome process; b. the development of the ultrasonic transducer involves knowledge of acoustics, vibration, materials, electronics, machinery, and even chemistry, medicine, and other disciplines. High-frequency ultrasonic transducers are small in size and require high precision, which puts forward higher requirements for transducer design, materials, and technology. Figure 1 shows a schematic diagram of a typical structure of a common one-dimensional array ultrasonic transducer, its structure includes an array element, a matching layer, a backing layer, an acoustic lens, and an array element connection, and the array element prepared from piezoelectric materials is a transducer core components [9]. For the piezoelectric ceramic material ultrasonic transducer, the acoustic impedance of the piezoelectric array

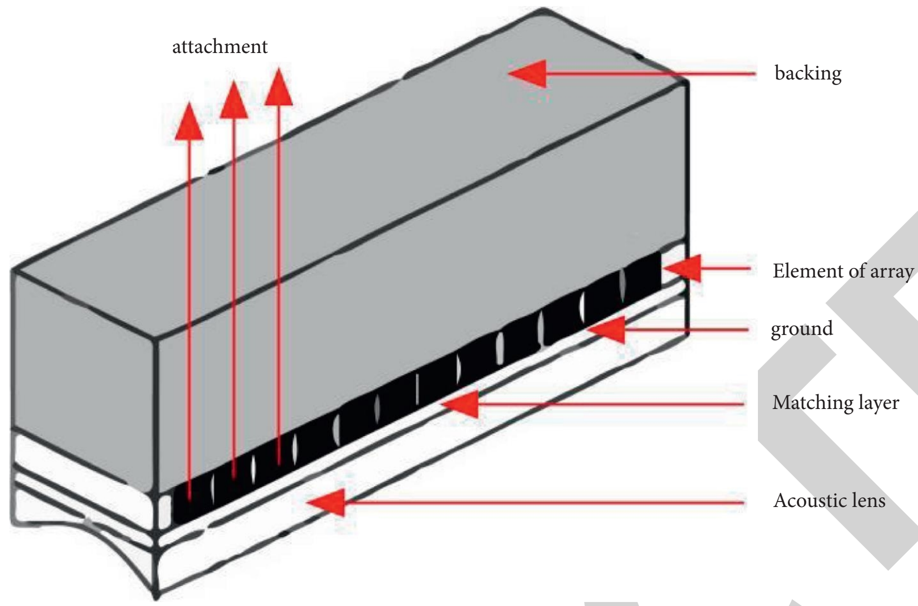

Figure 1: Structure diagram of ultrasonic linear array.

element (the product of the medium density and the speed of sound in the medium) is usually greater than the acoustic impedance of the matching layer and the backing layer, and at this time, the piezoelectric array element takes its fundamental resonance corresponding thickness.

The piezoelectric elements are equally spaced and sandwiched by the matching layer and the backing layer [10]. Because the array elements in the array are equally spaced, the transducer sound field will appear grating lobes at the angle φ due to the interference of the sound field between the array elements.

3.1.2. Digital Assembly Process System. When planning the digital process system, its digital assembly process system architecture is shown in Figure 2, and the realization of the CAPP digital process system can directly obtain the 3D model structure of the product through the TC-PDM system, forming a complete inheritance and associated management of product data; in the assembly process design stage, the assembly process of the product and the components in the process are defined according to the 3D model structure, and the assembly sequence and assembly path of the product are planned, and in the assembly process, the assembly animation simulation and, at the same time, the unified and standardized process resource data of the enterprise can be obtained through the MDM master data system, including equipment resources, tooling fixtures and materials, etc., in order to ensure that the process design process can be quickly invoked, thereby forming the optimal assembly process design [11].

After completing the 3D assembly process design, the system will be reviewed and signed through the digital process platform, and after the review and signing, it will be released to the workshop manufacturing end such as the MES system through the digital process platform, and the 3D process will be directly used to guide the workshop's 3D assembly manufacturing, thereby improving the assembly efficiency and assembly quality [12].

The digital assembly process platform consists of the digital process design platform Kaimu PDM client, Kaimu computer-aided process design software KMCAPP, and three-dimensional assembly process planning software KM3DAST [13]. The 3D assembly process design process is that after the Kaimu PDM client extracts the 3D model of the product through the TC system, the 3D assembly process planning software 3DAST software is used to design the 3D assembly process of the product and output it in the form of 3D animation. The process design workflow and process design process are shown in Figures 3 and 4.

3.2. Research on the Equivalent Circuit of Ultrasonic Transducer

3.2.1. Equivalent Circuit of Ultrasonic Transducer. Thickness-driven thin-film transducers are used in the AOTF system, and the thickness of each coating has an important influence on the working characteristics of the transducer, especially its impedance characteristics and bandwidth characteristics [14]. The Mason equivalent circuit is the basis for calculating the relevant performance parameters of the transducer, the frequency characteristics of the transducer loss, the 3 dB bandwidth of the transducer, the input resistance, and the input reactance can be obtained through the Mason equivalent circuit; thus, the theoretical input impedance matching resistance value of the transducer under the condition of the 3 dB bandwidth of the transducer is obtained [15]. In the impedance analysis of the ultrasonic transducer, we only need to know the relationship between the external parameters of the transducer; therefore, the transducer can be regarded as a matrix network, use the equivalent circuit to study its frequency characteristics, such as transducer loss and input impedance. The external

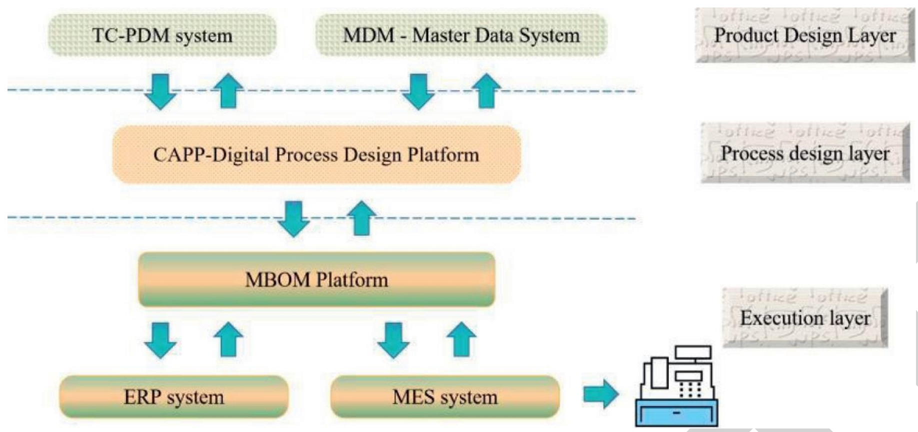

Figure 2: Digital assembly process system architecture.

Figure 3: 3D assembly process design workflow.

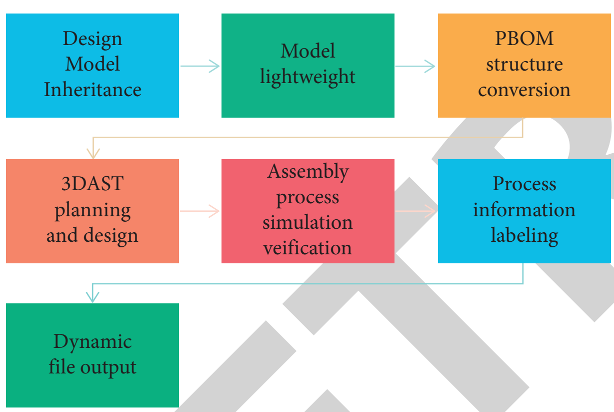

Figure 4: 3D assembly process design process.

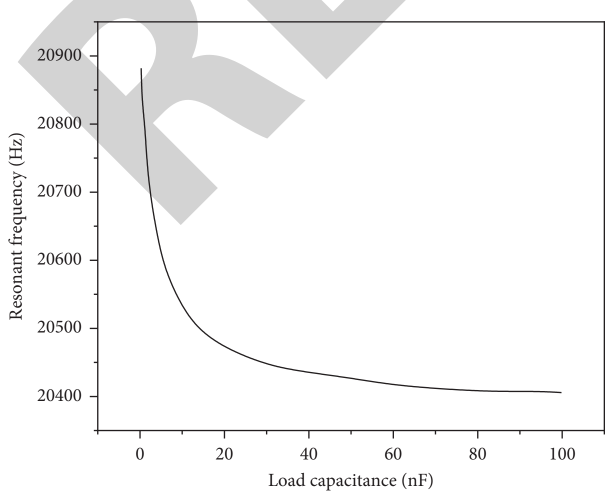

Figure 5: The curve of the resonant frequency changing with the load capacitance.

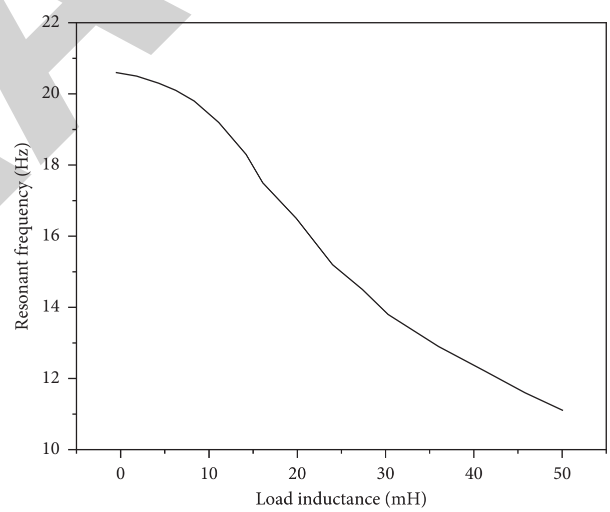

Figure 6: The curve of the resonant frequency changing with the load inductance.

parameters of the commonly used transducer are the voltage U and current I of the electrical terminal, the force F of the sound terminal, and the vibration velocity V of the particle. The relationship between F and V follows a similar Ohm's law ($U = RI$) $F = ZV$, where Z is the acoustic impedance. In view of the fact that bulk-wave acousto-optic devices always use thin-film transducers in thickness-driven mode, the Mason equivalent circuit is an important basis for frequency characteristics such as transducer loss, transducer 3 dB bandwidth, input resistance, and input reactance [16]. The left transfer matrix of the piezoelectric layer is expressed as shown in the following formula:

Table 1: Diffraction efficiencies at different frequencies.

Drive signal frequency/MHz	115	120	130	140	150	160	170	180
Measured wavelength/nm	620.0	602.6	565.6	534.6	508.3	484.8	465	448.5
Theoretical impedance diffraction efficiency	64.84	62.58	54.17	53.69	51.50	31.86	37.24	33.96
$(12 - j \times 5.5)$/%	76.12	74.79	65.51	67.86	67.09	45.13	51.83	40.55

$$\begin{pmatrix} U \\ I \end{pmatrix} = \mathbf{A}_0' \begin{pmatrix} U' \\ I' \end{pmatrix}. \tag{1}$$

The transfer matrix on the left side of the Mason equivalent circuit is expressed as shown in the following equation:

$$\mathbf{A}_0' = \frac{1}{\phi} \begin{pmatrix} 1 & \dfrac{i\phi^2}{\Omega C_0} \\ i\Omega C_0 & 0 \end{pmatrix}. \tag{2}$$

The transfer matrix of the left part of the Mason equivalent circuit is expressed as shown in the following equation:

$$\mathbf{A} = \begin{pmatrix} \dfrac{Z_1 + Z_2}{Z_2} & \dfrac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_2} \\ \dfrac{1}{Z_2} & \dfrac{Z_2 + Z_3}{Z_2} \end{pmatrix}. \tag{3}$$

The transfer matrix of the entire piezoelectric layer is expressed as shown in the following formula:

$$\begin{aligned} \mathbf{A}_0 &= \mathbf{A}_0' \times A \\ &= \frac{1}{s\phi} \begin{pmatrix} 1 & \dfrac{i\phi^2}{\Omega C_0} \\ i\Omega C_0 & 0 \end{pmatrix} \cdot \begin{pmatrix} (\cos\gamma - z_1 \tan\gamma_1 \sin\gamma) & iZ_0 (\sin\gamma + z_1 \tan\gamma_1 \cos\gamma) \\ \dfrac{i\sin\gamma}{Z_0} & 2(\cos\gamma - 1) - z_1 \tan\gamma_1 \sin\gamma \end{pmatrix}. \end{aligned} \tag{4}$$

3.2.2. Impedance Matching Design. In the actual test, it is found that because the length of the top electrode of the transducer is too small, the manufacturing process is difficult. The ultrasonic energy of the monolithic structure is distributed in a considerable angle range, and each frequency only uses a certain direction, and the sound energy, so that the ultrasonic energy is lower, will affect the diffraction efficiency [17]. In order to solve the above problems, we adopt a multichip structure of the transducer, which is the result of a coherent superposition of ultrasonic waves excited by each transducer in the main direction of the ultrasonic energy. In order to achieve full tracking of all frequencies, each transducer must be driven by an independent power supply, and the phase difference between two adjacent transducers must vary with frequency, so the fully tracked driving power supply will be very complicated, and the user requirements cannot be met, so a driving power supply can be used to achieve different phase differences between two adjacent transducers through different connection methods, and when the transducers are connected in parallel, the direction of the electric field applied to the adjacent transducers is the same, the phase difference is 0, and the same phase does not change with frequency. When connected in series, the electric field applied to the adjacent transducers is opposite in direction, the polarization direction of lithium niobate is opposite, and the phase difference is π. Therefore, the use of planar multipiece series transducers is more efficient than single-piece ultrasonic utilization and diffraction efficiency [18]. The planar multipiece series structure transducer is connected in series in structure, but in the case of the same driving power supply, the positive and negative electrodes of each lithium niobate segment are, respectively, connected to the positive and negative electrodes of the transducer matching circuit; in this way, it can be regarded as equivalent that each lithium niobate segment is connected in parallel. The ultrasonic transducer is a nonlinear capacitive load, and its output voltage and current have a certain phase difference at the operating frequency, and this phase difference makes the output power not reach the expected maximum value [19]. At present, most of the transducer matching methods are as follows: a reverse reactance is connected in parallel or in series at both ends of the transducer, so that the transducer becomes a pure resistance. A transformer is added between the driving signal source and the transducer, and the pure resistance value of the transducer is transformed to be equal to the internal resistance of the driving signal source, and when the internal resistance of the driving signal source and the load are equal, the load can obtain rated power. However, in this matching method, there is a heating loss of the varistor transformer, which will absorb a lot of power, and as only 3-4 W transducer driving power is required, this loss is very large, and the energy storage LC element matching network is used, almost lossless [20]. By changing the value of the electrical load connected to the transducer, the following relationship diagrams can be obtained, as shown in Figures 5 and 6, when a capacitive load is connected, see Figure 5. When an inductive load is connected, see Figure 6.

When the piezoelectric ultrasonic transducer is connected to an electrical load, no matter whether the electrical load is capacitive or inductive, the resonant frequency of the transducer shows a trend of monotonically decreasing with the increase of the electrical load value.

4. Analysis of Results

Using the HR4000 spectrometer, the experimental test was carried out on the experimental system platform, the visible light was transmitted through the ultrasonic transducer, and the 0-level light was aimed at the HR4000 spectrometer probe, and in the spectrometer software, real-time observation of diffraction and diffraction intensity in the frequency range of 115 to 180 MHz occurs, by continuously changing the impedance and LC value of the ultrasonic transducer, and finally, it can be obtained from the experiment that when the impedance of the transducer is $10 - j \times 5$, the diffraction intensity crater decreases the most, and the diffraction efficiency is the highest [21]. In order to facilitate the comparison of the diffraction intensity between the theoretical impedance value and the optimal impedance value, several points were selected in the diffraction range of 115–180 MHz for data collection and diffraction pattern fitting, which was expressed by the number of collected photons, and its unit was in the count value [22]. Using MATLAB to process the data collected by the spectrometer, the theoretical and optimal impedance diffraction efficiencies are obtained, as shown in Table 1.

The ultrasonic transducer adopts a planar multichip series structure, and the ultrasonic waves excited by adjacent unit transducers are superimposed coherently, so that the ultrasonic energy is increased compared with that of a single chip, and the spectral diffraction efficiency is increased. The matching circuit adopts the energy storage LC element matching network technology, which has the following points compared with the traditional matching technology with resistance transformers: (1) No heat, almost no loss, and higher diffraction efficiency. (2) Long-term use, better stability. (3) There are only inductors and capacitors in the matching circuit, and the number of inductors is much less than that of capacitors, which is more economical. The transducer multichip structure and LC matching network circuit of the ultrasonic transducer system can make the AOTF system achieve better results, and the diffraction efficiency can reach more than 70%, which is of great significance to the research and development of the current digital assembly process system.

5. Conclusion

In order to solve the problem of design efficiency of the digital assembly process, the author proposes a research using ultrasonic transducer technology. The main content of this research is to study the ultrasonic transducer elements according to the basic structure of the ultrasonic transducer. Through the study of equivalent circuit of ultrasonic transducer, the model of impedance matching design is constructed. Finally, the feasibility of ultrasonic transducer technology is obtained through experiments. Ultrasonic transducer is a strong nonlinear time-varying system, and its impedance and other characteristics are very different at different operating frequencies. In the application of ultrasonic transducers, frequency characteristics analysis and impedance matching of ultrasonic transducers are required, in order to achieve the highest transmission efficiency and the best waveform effect. The transducer multichip structure and LC matching network circuit of the ultrasonic transducer system can make the AOTF system achieve better results, and the diffraction efficiency can reach more than 70%, which is of great significance to the research and development of the current digital assembly process system.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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