CHAPTER 4 PROPOSED METHOD

4.1 Experimental Process

Figure 4.1 presents how to complete the thesis experimental process. Firstly, to study the obtained capacitorless bandpass BIQUAD filter and match the bias current with the BIQUAD parameter. To tune the data set of a selected BIQUAD point and generate the response of a tuning result. Considering the tuning error, if the tuning result is satisfactory, then the process finishes. Nevertheless, if the tuning result is not satisfactory, the iterative process will be used to collect the new training sets and then tune them again.

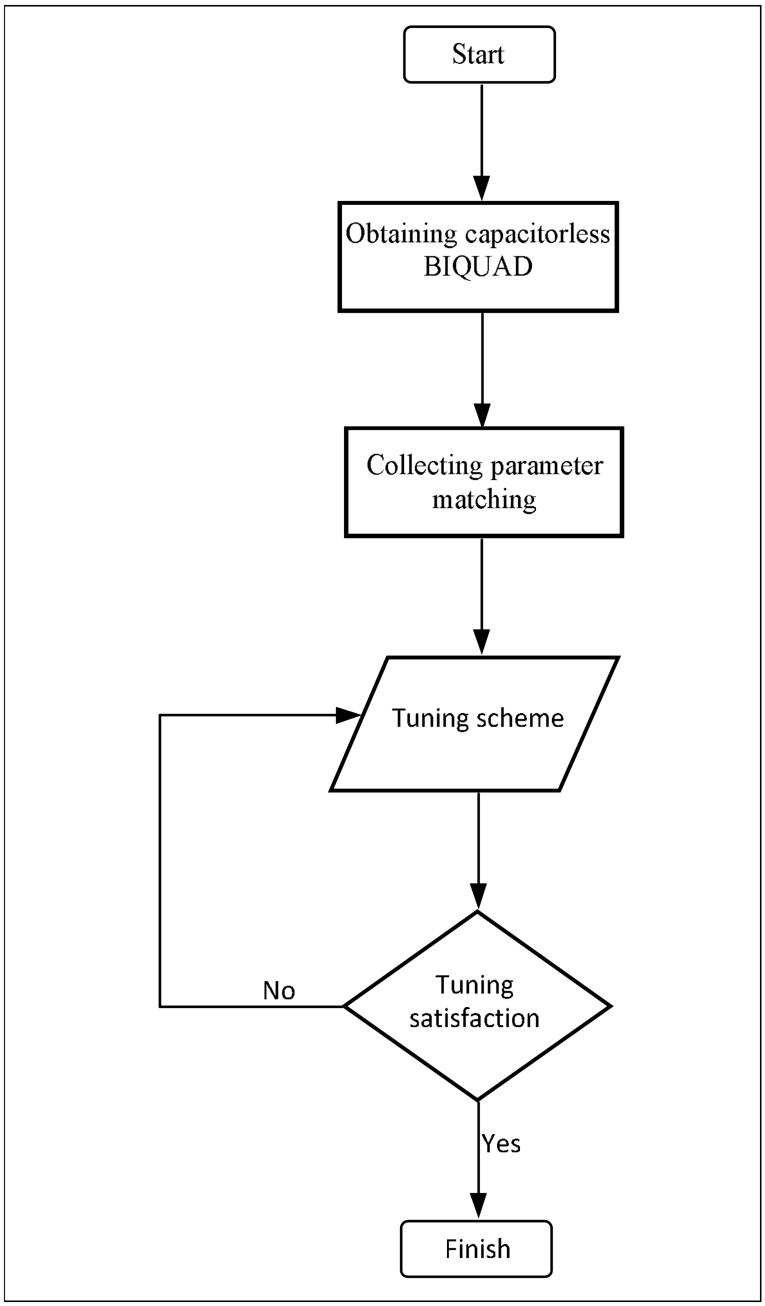

Figure 4.1 The experimental process

4.2 Utilizing an Artificial Neural Network to be Applied

The general form of a bandpass BIQUAD is composed of three main parameters, which are the gain (K), pole frequency (ω_p), and Q-factor (Q_p) [12]. According to the experiment BIQUAD, there are three bias currents (I_1, I_2, and I_3) to be adjusted. The associate ANN, applied to utilize the studied BIQUAD, is operated but being opposite to the actual circuit as the BIQUAD's parameters are taken as an input which is employed to estimate the corresponding bias currents. Therefore, the operation of the trained ANN is functionalized:

$$\begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ \vdots \\ I_n \end{bmatrix} = \mathbf{F}_{ANN}\left(\begin{bmatrix} K \\ \omega_p \\ Q_p \end{bmatrix}\right) \tag{4.1}$$

Where F_{ANN} is a virtual function representing the transferring of BIQUAD's requirements to the actual circuit's parameters based on the trained ANN. The training process treats a requirement vector as an input and recognizes the vector of the corresponding circuit's parameters as an output.

4.3 Data Collection

4.3.1 Pre-process Collection

To create a set of predefined bias points, the range of a bias current is quantized based on a desired quantizing resolution (Δ_D), which results in the minimum quantizing level (L_Q).

$$L_Q = \left\lceil \frac{I_{\max} - I_{\min}}{\Delta_D} \right\rceil + 1 \tag{4.2}$$

Based on full combination of all bias currents, the total amount of the predefined records (T_R) are simply:

$$T_R = L_Q^n \tag{4.3}$$

Where n is the number of a circuit's parameters. Finally, the actual quantizing resolution is:

$$\Delta_A = \frac{I_{\max} - I_{\min}}{L_Q - 1} \tag{4.4}$$

According to eq. (2) and (4), the actual resolution is always lower than or equal to the desired resolution.

4.3.2 Initializing the Training Set

Figure 4.2 presents the organized distribution of bias points which usually generates the chaotic BIQUAD points displayed in Figure 4.3. To select an appropriate initial training set, the gathering cube is centered at the specific point representing the BIQUAD specification as displayed in Figure 4.3. To initialize the training set, the volume of the gathering cube can be increased or decreased until the amount of the BIQUAD points inside the cube is equal to the size of the training set.

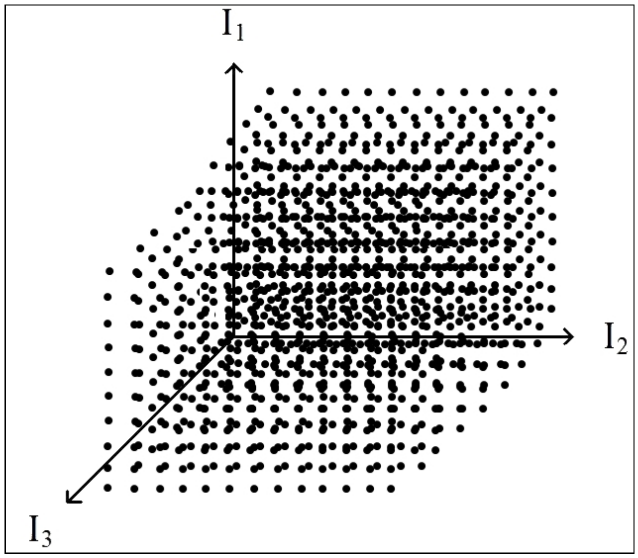

Figure 4.2 Predefined bias points

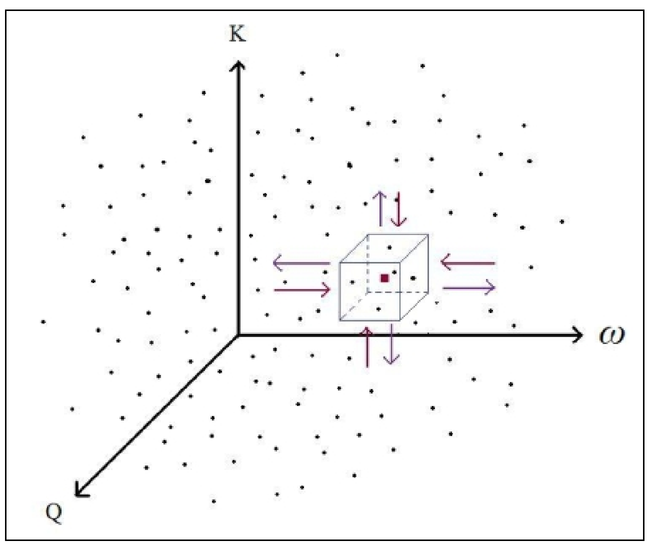

Figure 4.3 The matching BIQUAD parameter

4.4 Sequential Training and Utilization

As the training set is small and contains only samples that are close to the desired BIQUAD, there is no division of the data. Therefore, the training of the deployed ANN is conducted without validation and test. If there is a significant training error, it will be relieved through the sequential training process presented by the flowchart in Figure 4.4.

Firstly, the ANN is trained with the initial training set. Once the ANN is completely trained, it is utilized to estimate the bias currents which are exploited to generate the practical response based on the HSPICE simulation. If the deviation in the BIQUAD's parameters of the generated response is considered insignificant, the process finishes. If not, the training set is updated if the recently generated response is better than the worst member presented in the present training set. Then, the ANN is trained again. These tasks can be looped forever if there is no second termination criterion which is the reaching of the maximum loop that strongly indicates the failure of tuning.

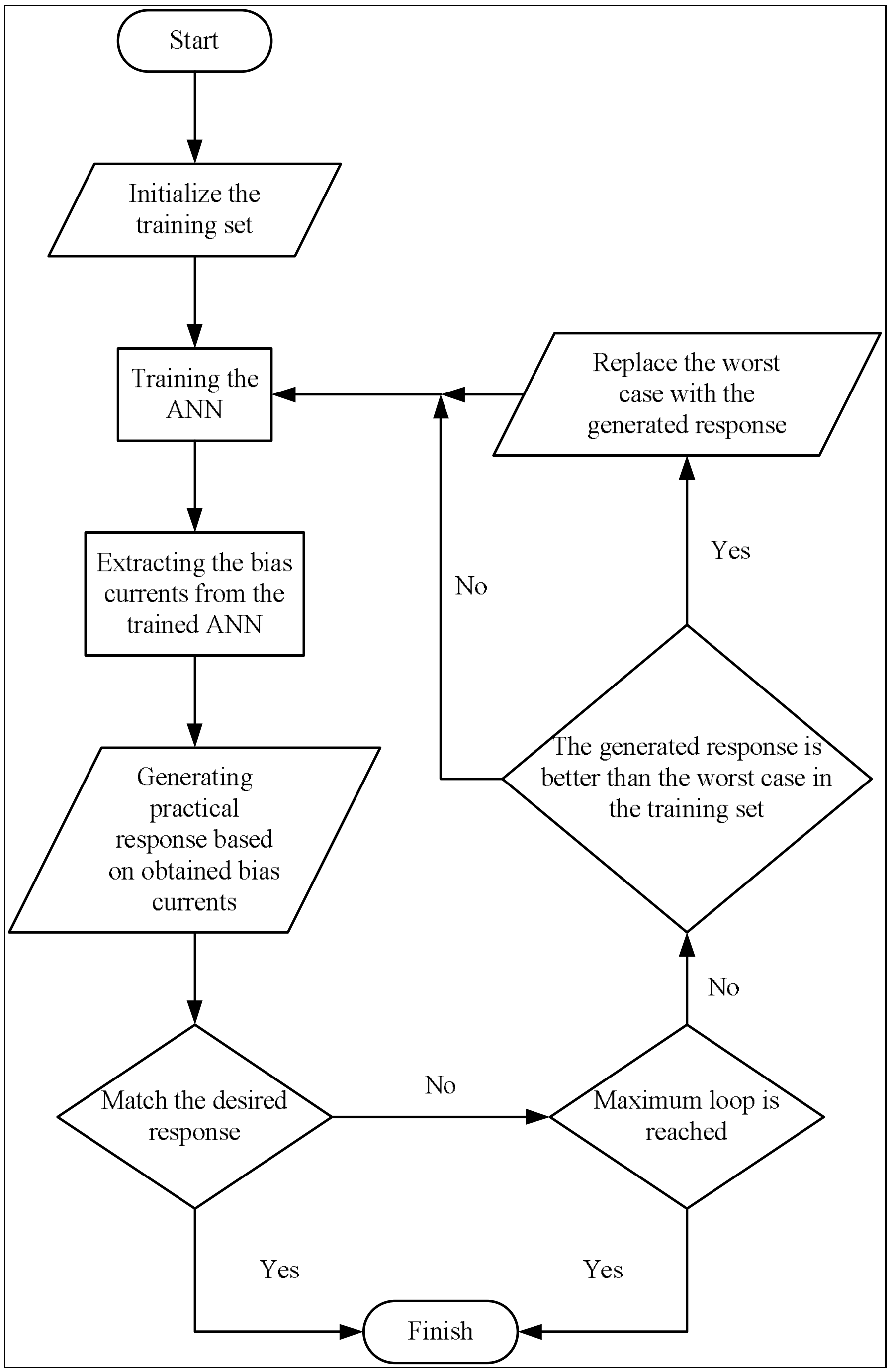

Figure 4.4 The sequentially trained data set

4.5 Tuning Scheme

The key characteristics of the proposed process are the less complex ANN which is sequentially trained with a very small training set. Therefore, the predefined bias point must be collected with quite low resolution of the bias current to cover most of the operating regions. Key parameters concerning the implementation of a tuning scheme are listed in Table 4.1.

Table 4.1 Key parameters of sampled tuning scheme

Parameter	Value
Resolution	10µA
Minimum bias current	10µA
Maximum bias current	300µA
Size of predefined bias point	24,389 records
Final iteration of sequential training	20th
ANN type	Cascade-forward (CF)
Number of hidden layers	1
Size of each layer except the output	10
Size of output layer	3
Training goal	0.1
Size of training set	20