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Analysis The IIR Filter Design Using Particle Swarm Optimization Method

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ABSTRACT- In this paper we Analysis the IIR filter design using PSO method .The simulations of designing IIR have been done and the simulation results show that the method of IIR tilter design proposed in this paper is better than the method of genetic algorithm (GA) and immune algorithm (IA) not only in the convergence speed but also in the performance of filter.

Key words: - IIR, PSO, Matlab, Magnitude Response, Pole-Zero.

I. INTRODUCTION

A digital filter is a system that performs mathematical operations on a sampled, discrete-time signal to reduce or enhance certain aspects of that signal. This is in contrast to the other major type of electronic filter, the analog filter, which is an electronic circuit operating on continuous-time analog signals. There are two major classes of digital filters namely, finite impulse response (FIR) filters and infinite impulse response (IIR) filters depending on the length of the impulse response. Discrete component dependent design, prone to high component tolerance sensitivity, poor accuracy, highly susceptible to thermal drift and large physical size are the major retractions of analog filter implementation. On the contrary, digital filter performs mathematical operation on a sampled, discrete timed signal to achieve the desired features with the help of a specially designed digital signal processor (DSP) chip or a processor used in a general purpose computer. Digital filters are broadly classified into two main categories namely; finite impulse response (FIR) filter and infinite impulse response (IIR) filter. The output of FIR filter depends on present and past values of input, so the name nonrecursive is aptly suited to this filter. On the other hand, the output of IIR filter depends not only on previous inputs, but also on previous outputs with impulse responses continuing forever in time at least theoretically, so the name recursive is aptly suited to this filter; anyway, a large memory is required to store the previous outputs for the recursive IIR filter. Hence, due to these aspects FIR filter realization is easier with the requirement of less memory space and design complexity. Ensured stability and linear phase response over a wide frequency range are the additional advantages. On the other hand, IIR filter distinctly meets the supplied specifications of sharp transition width, less pass band ripple and more stop band attenuation with ensured lower order compared to FIR filter. As a consequence, properly designed IIR filter can meet the magnitude response close to ideal and more finely as compared to FIR filter. Due to these challenging features with wide field of applications, performances of IIR filters designed with various evolutionary optimization algorithms are compared to find out the optimization effectiveness of the algorithms and the best optimal IIR filters.

2. IIR FILTER

IIR filters are digital filters with infinite impulse response. Unlike FIR filters, they have the feedback and are known as recursive digital filters.

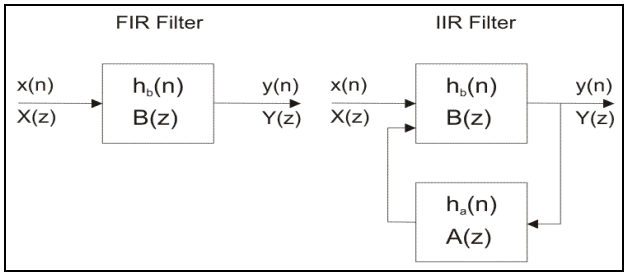

Fig. 1 FIR and IIR filters

The IIR filters have much better frequency response than FIR filters of the same order. Unlike FIR filters, their phase characteristic is not linear which can cause a problem to the systems which need phase linearity. For this reason, it is not preferable to use IIR filters in digital signal processing when the phase is of the essence. FIR

filters can have linear phase characteristic, which is not typical of IIR filters. When it is necessary to have linear phase characteristic, FIR filters are the only available solution. In other cases when linear phase characteristic is not necessary, such as speech signal processing, FIR filters are not good solution. IIR filters should be used instead. The resulting filter order is considerably lower for the same frequency response. The IIR filter transfer function is a ratio of two polynomials of complex variable z-1. The numerator defines location of zeros, whereas the denominator defines location of poles of the resulting IIR filter transfer function.

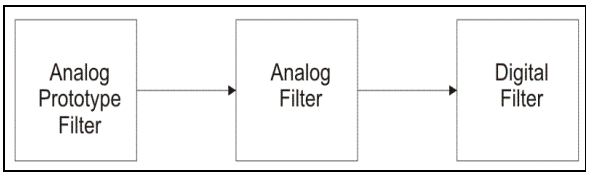

Fig. 2. Design method using analog prototype filter

TYPES OF IIR FILTER

- Butterworth filters.
- Chebyshev filters.
- Inverse chebyshev filters.
- Elliptic filters.

The IIR filter designs differ in the sharpness of the transition between the pass band and stop band, where they exhibit various characteristics.The main advantage digital IIR filters have over FIR filters is their efficiency in implementation, in order to meet a specification in terms of pass band, stop band, ripple, and/or roll-off. Such a set of specifications can be accomplished with a lower order IIR filter than would be required for an FIR filter meeting the same requirements. If implemented in a signal processor, this implies a correspondingly fewer number of calculations per time step. FIR filters can be easier to design, for instance, to match a particular frequency response requirement. This is particularly true when the requirement is not one of the usual cases high-pass, low-pass, notch, etc. which have been studied and optimized for analog filters. IIR filters are the potential for limit cycle behavior when idle, due to the feedback system in conjunction with quantization.

3. PARTICLE SWARM OPTIMIZATION

The PSO algorithm is an adaptive algorithm based on a social-psychological metaphor; a population of individuals (referred to as particles) adapts by returning stochastically toward previously successful regions. Particle Swarm has two primary operators: Velocity update and Position update. During each generation each particle is accelerated toward the particles previous best position and the global best position. The new velocity value is then used to calculate the next position of the particle in the search space. PSO is a flexible, robust population-based stochastic search or optimization technique with implicit parallelism, which can easily handle with non-differential objective functions, unlike traditional optimization methods.

The particle swarm algorithm is used here in terms of social cognitive behavior. It is widely used for problem solving method in engineering. In PSO, each potential solution is assigned a randomized velocity, are "flown" through the problem space. Each particle adjusts its flying according to its own flying experience and its companions' flying experience. The ith particle is represented as $X_i = (x_{i1,} x_{i2,} \text{-------} x_{id})$. Each particle is treated as a point in a D-dimensional space. The best previous position (the best fitness value is called pBest) of any particle is recorded and represented as $P_i = (p_{i1}, p_{i2}\text{------}p_{id})$.Anther "best" value (called gBest**)** is recorded by all the particles in the population. This location is represented as $P_g = (p_{g1,} p_{g2}\text{-----}p_{gd})$. A t each time step, the rate of the position changing velocity (accelerating) for particle i is represented as $V_i = (v_{i1,} v_{i2}\text{-----}v_{id})$. Each particle moves toward its pBest and gBest locations. The performance of each particle is measured according to a fitness function, which is related to the problem to be solved [3].

4. SIMULATION RESULTS

This section represents the simulation frame work for the design of IIR filter using PSO. Enter the value of t1 = 35, Enter the value of t2 = 40, Enter the central frequency = 100

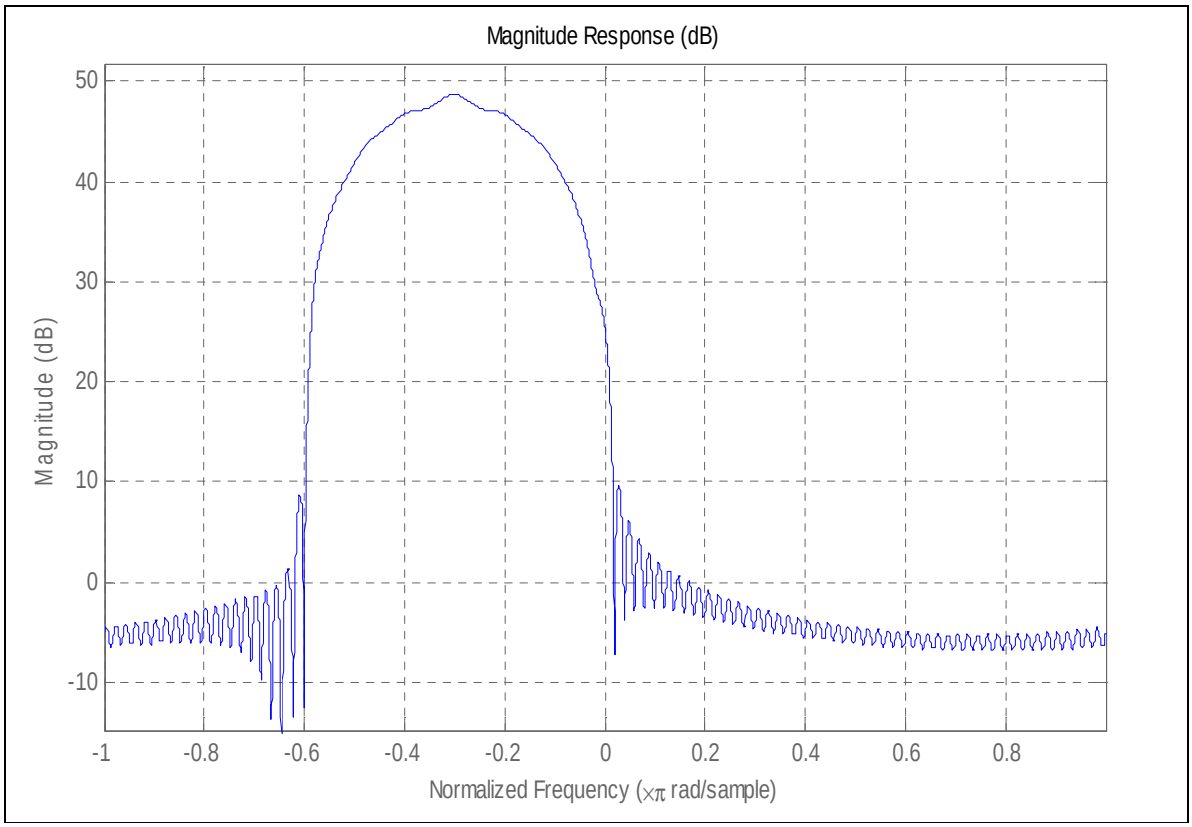

Figure 3, Magnitude Response

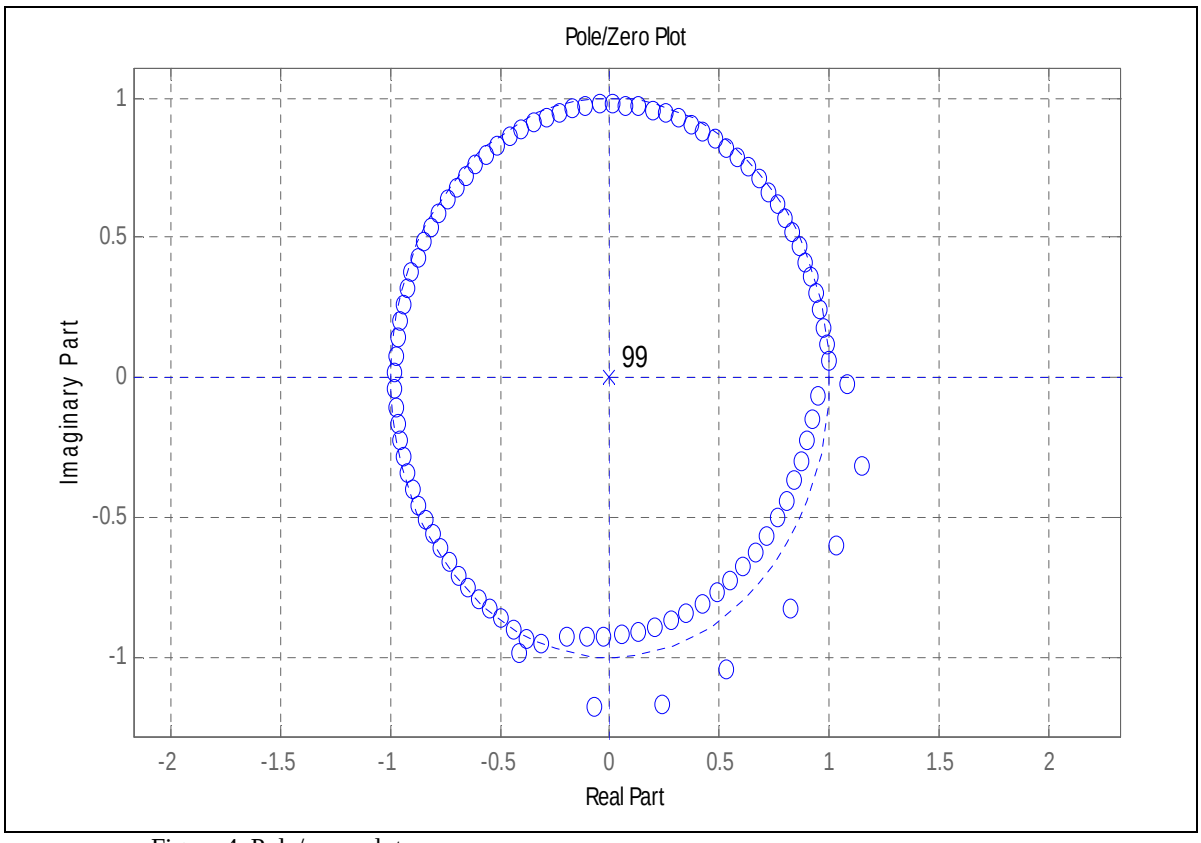

Figure 4, Pole/ zero plot

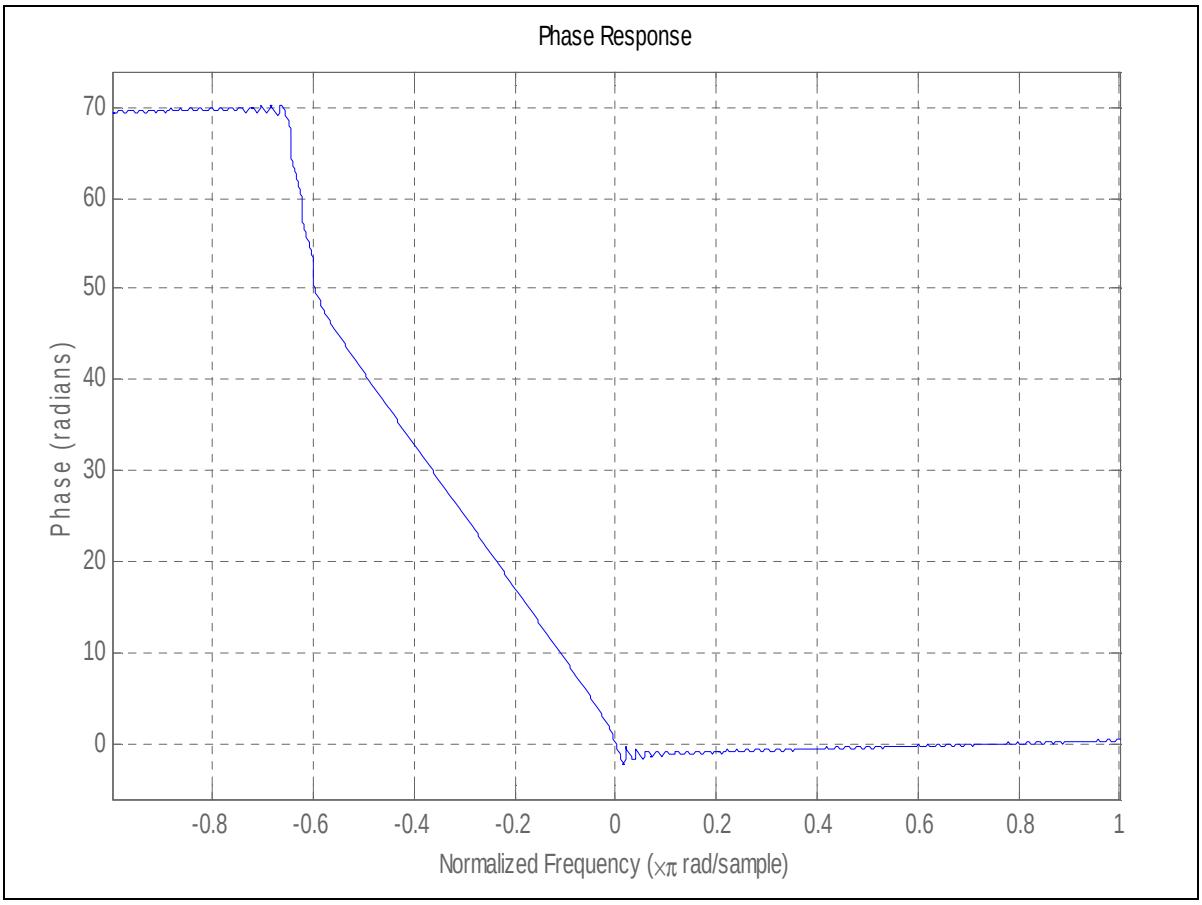

Figure 5, Phase Response

5. CONCLUSION AND FUTURE SCOPE

To analysis filters with special requirements such as a trade-off in norms or concerning quantization effects there is a need of more general optimization techniques.IIR filters are widely used in the field of signal processing due to its distinguishing features such as: the stability, linear phase and easiness for realization. IIR filters are used for applications where linear characteristics are not of concern. IIR filter is better for lower order tapping. IIR filters must have at least one pole. It is a recursive filter means it has feedback. IIR filters may be unstable depending on the location of poles where as FIR filter is always stable. Pole-Zero plots is an important tool. It can be used to determine stability. We can distinguish from pole-zero plots whether the filter is low pass, high pass, band pass or band stop. Low pass filters have poles closer to the origin than zeros. They may not have zeros at all. High pass filters will have the zeros close the origin and will probably have at least one on the origin.

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