



### Industrial Consultancy & Sponsored Research (IC&SR)

#### Method and Electronic Device for Estimating Frequencies of Multiple Sinusoids

#### IITM Technology Available for Licensing

##### PROBLEM STATEMENT

- In the present instant, there is a recent talk on **unbiased estimators** like s maximum likelihood (ML) estimator has the **lowest threshold** but is computationally the **most expensive**.
- There are many estimating methods like Estimation of Signal Parameters via Rotational Invariance Technique (ESPRIT), Multiple Signal Classification (MUSIC), Minimum Norm (Min-Norm), etc. are being used having flaws in terms of **signal to noise ratio (SNR)** & **threshold values**.
- Hence, there is a need to address the issues.

##### INTELLECTUAL PROPERTY

**IITM IDF Ref. 1983; IN Patent No: 398608**  
**PCT Application No. PCT/IN2021/050279**  
**US Application No. US17/906,411**

##### TECHNOLOGY CATEGORY/MARKET

**Technology:** Frequency Estimator Engine;  
**Industry & Application:** ICT, Wireless;  
**Market:** The global frequency converter market is projected to grow at a **CAGR of 9.1%** during **2024-2032**.

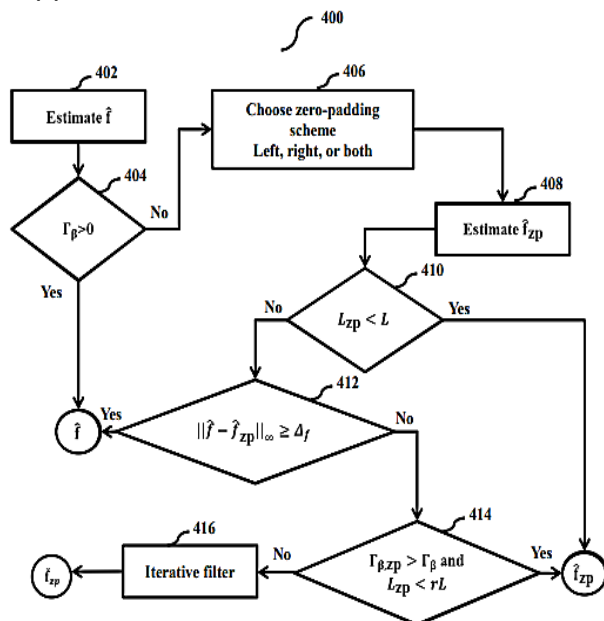
##### TRL (TECHNOLOGY READINESS LEVEL)

**TRL-4**, Proof of Concept ready, tested in lab.

##### TECHNOLOGY

- The present invention describes a method for estimating frequencies of multiple sinusoids.
  - Said method comprises a few steps stated hereinbelow:
1. Receiving a signal, by an electronic device & estimating an **initial frequency** of each of the **multiple sinusoids** present in the **received signal**.
  2. Further, determining first candidate parameter is **less than zero**, wherein the candidate parameter is function of an estimated signal to noise ratio (SNR) & estimated threshold.

- Moreover, following steps states that **performing zero-padding** on the received signal, & **re-estimating** frequencies obtained from zero-padded version of the received signal.
- Furthermore, **validating** the re-estimated frequencies obtained from zero-padded version of received signal based on validation criteria.
- Thereafter **predicting the re-estimated frequencies** or the initial frequencies as optimal frequencies based on the validation.
- The electronic device is shown in Fig 2. The present invention provides the solution is based on subspace based approach.



**Fig.1: Illustrates the flow diagram of a method for estimating frequencies of multiple sinusoids;**

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### KEY FEATURES / VALUE PROPOSITION

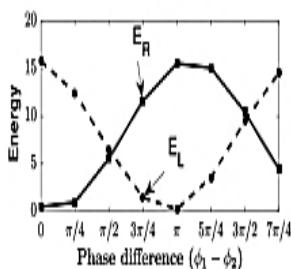
#### ❖ Technical Perspective:

- The **frequency estimator engine** includes an initial frequency estimator, an energy-based zero-padding controller, an outlier detector, and an optimal frequency estimator.
- The method includes **refining re-estimated frequencies** using **iterative filtering**.
- Performing **zero-padding** on the received signal if a first candidate parameter is **less than zero**.
- **Re-estimate frequencies** obtained from the **zero-padded** version of a received signal and validate the re-estimated frequencies.
- Decide whether the **re-estimated frequencies** or the **initial frequencies** as **optimal frequencies** based on the **validation**. (Refer Fig.2)

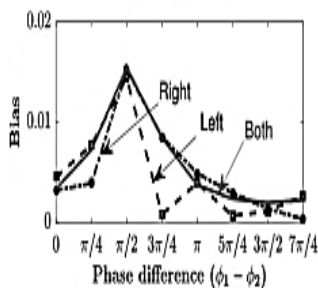
#### ❖ Industrial Perspective:

- The updated estimated is **improved** and the procedure is **iterative & cost-effective** during each iteration.

### IMAGE



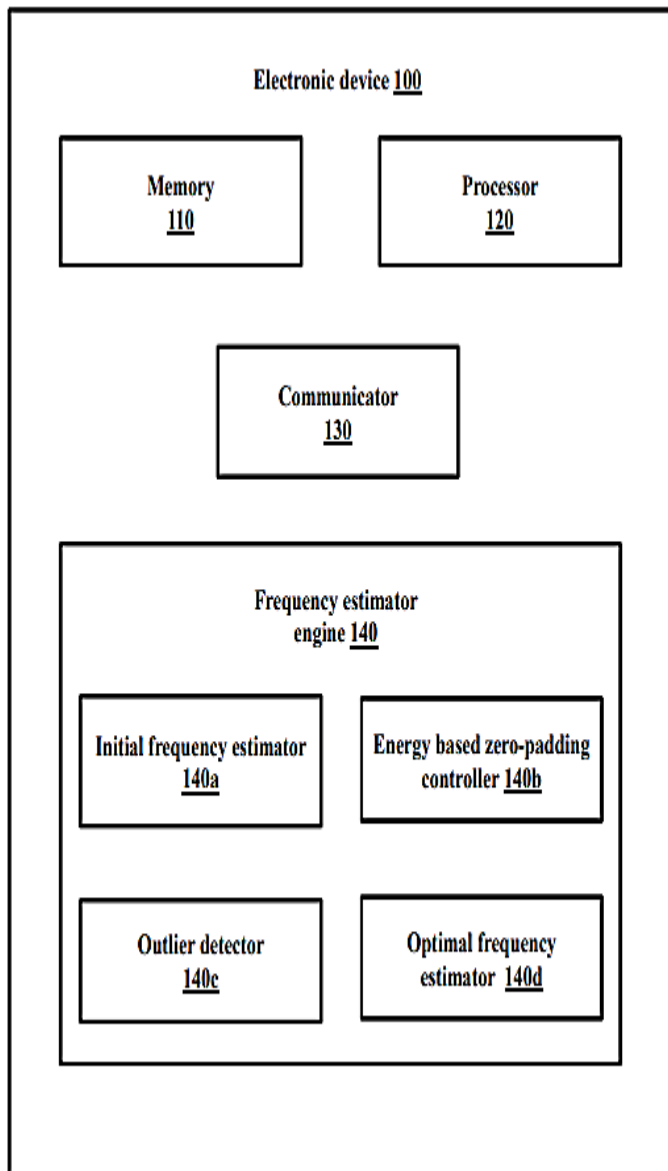
(a)



(b)

**FIG.2a & FIG. 2b illustrate energy levels  $E_L$  &  $E_R$  for two sinusoids for various phase differences and comparison of bias in the ESPRIT estimates for different zero-padding schemes (SNR=15dB);**

### IMAGE



**FIG.3 illustrating a block diagram of an electronic device for estimating frequencies of multiple sinusoids;**

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