

# Frequency Offset Synchronization using Luise-Reggiannini (LR) Technique

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<i>Abstract—A brief description about the Frequency estimation using the Luise and Reggiannini Technique.</i>		

- Calculation of Auto Correlation  $R(k)$  which is complex oscillation with added gaussian.

$$R(k) \triangleq \frac{1}{N-k} \sum_{i=k+1}^N r_i r_{i-k}^*, 1 \leq k \leq N-1 \quad (1.0.4)$$

Where N is the length of the received signal.

This Estimated part of the technique is only for the small frequency offset(Upto 800Hz). This is the major drawback.

### B. Exact

For large frequency, This yields a better approximation even for frequency offset as large as 40 MHz.

$$\Delta \hat{f} \approx \frac{1}{2\pi T_s} \frac{\sum_{k=1}^M \text{Im}(R(k))}{\sum_{k=1}^M k \text{Re}(R(k))} \quad (1.0.5)$$

Constraints on M is same as 1.0.3.

## 1. LR TECHNIQUE-ACTUAL APPROXIMATION

### A. Estimated

[1] This is true for small frequency offset , as what we observed , it is true until 800 Hz frequency offset.

$$\Delta \hat{f} \approx \frac{1}{\pi T_s (M+1)} \arg\left(\sum_{k=1}^M R(k)\right) \quad (1.0.1)$$

Where  $R(k)$  is the AutoCorrelation,  $T_s$  is the sampling time.

Conditions:

$$\Delta \hat{f} : T_s \geq \frac{1}{2\Delta f} \quad (1.0.2)$$

and

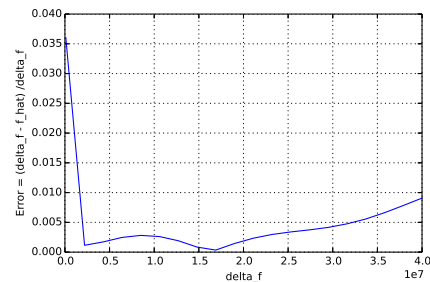
$$M : M\Delta f T_s \ll 1 \quad (1.0.3)$$

## 2. PRACTICAL VALUES

- 1) Signal Length  $N = 36$
- 2) frequency offset  $\Delta f = 5\text{MHz}$
- 3)  $T_s = 1\text{e-}9$
- 4) Central frequency  $F_c = 25\text{ GHz}$ . But  $F_c$  isn't required anywhere in code.
- 5)  $M = \frac{N}{2} = 18$

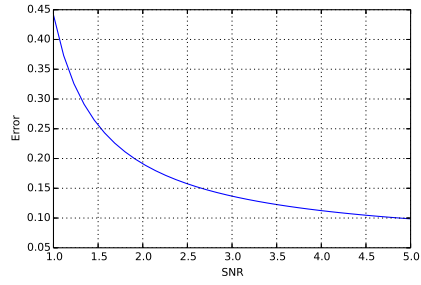
## 3. PLOTS

### A. For the fixed SNR



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*B. For the fixed frequency offset of 5 MHz*



## REFERENCES

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