Analysis, Measurement and design of optimal and suboptimal MLSE Phase Tracking

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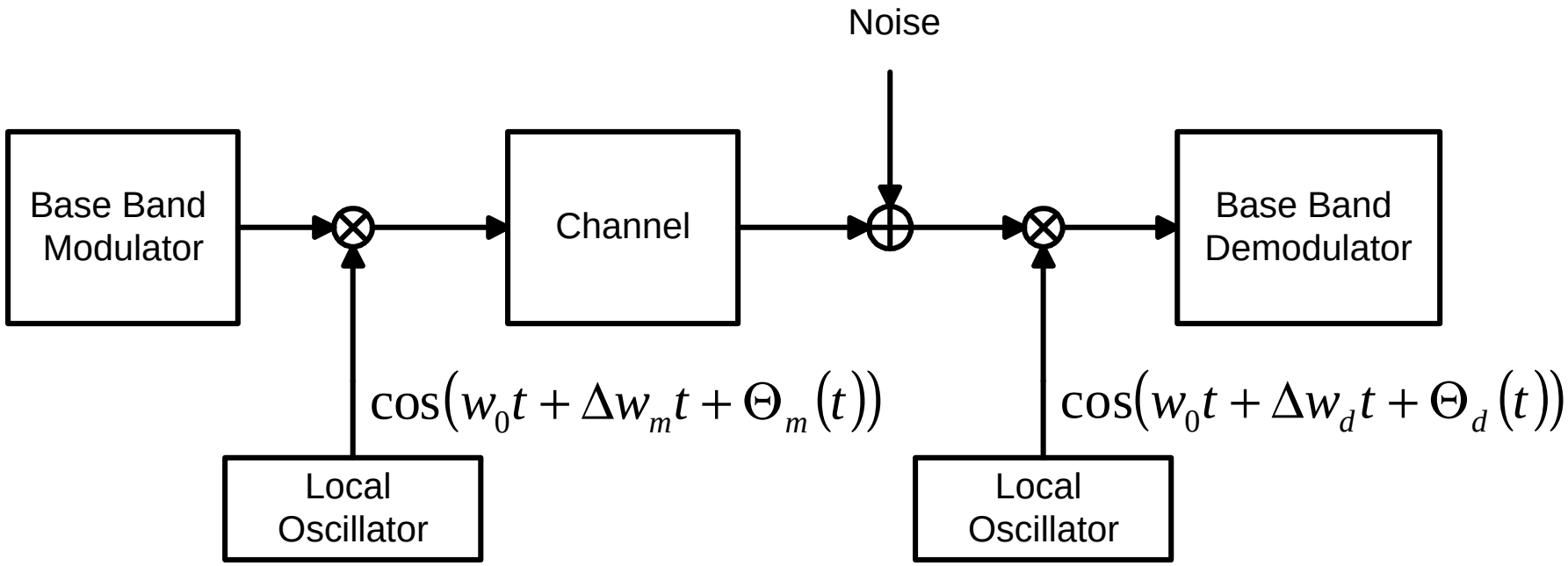
Outline

- The phase noise problem
- Maximum likelihood phase tracking methods
- Performance analysis of Maximum likelihood phase tracking methods
- Verifing analysis using a real radio system
- Synthesizer optimization

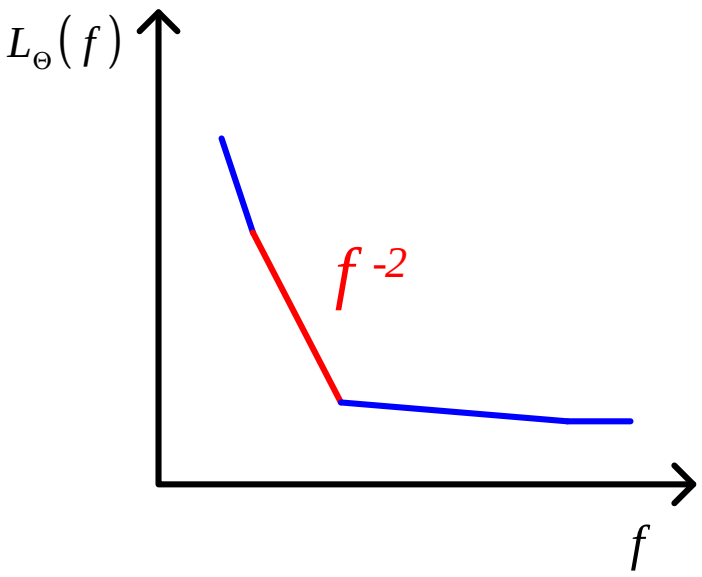
Phase noise in band-pass communication system



The local oscillator phase (Θ_m , Θ_d) is randomly varying, causing the ***phase noise*** *problem*

Phase Noise Sources

Phase noise spectrum



- Phase noise occur in any oscillator. It is amplified as the reference oscillator is multiplied to high carrier frequencies.
- The synthesizer loop and the VCO in it contribute their share.
- The phase noise in high frequencies becomes a real obstacle for communications.

PLL limitations

- Simple and easy to implement
- Easy to optimize for various SNR/phase noise spectrums
- May fail in high phase noise (e.g. 60 GHz)
- May fail in low SNR
- Problems enhanced in coded system :

  requires delay in loop, or work on low SNR of coded symbols

Joint Symbol-Phase MLSE

- Joint maximum likelihood for code and phase sequences
- Implemented by the Viterbi algorithem
- Discretize the phase value, each Trellis state constructed from a phase value & code state pair
- At each node, determine the sequence of phase & coded symbol with max metric to be the survivor
- **Optimal performance at the expense of high complexity due to the large number of states**

Per-Survivor Processing (PSP)

- Viterbi algorithm with only L code states
- Each state maintains a separate PLL
- Update each PLL with survivor path decision
- Complexity O(L)
- Phase tracking with coding, no delay in PLL

  è superior to conventional PLL
- Based only on past information

  è inferior to phase-symbol MLSE

MLSE & PSP Analysis

- No sufficient analytical analysis available prior to our research
- We have developed analytical expressions for the error rate of MLSE and PSP
- We have achieved important insights
- Based on insights and error rate expressions we can compare codes performances and design good codes for MLSE and PSP

Verify analysis using a real radio system

- We plan to compare performance of PLL,PSP,MLSE on “real world” system and verify the accuracy of the developed analytical expressions
- We plan to use phase noise of 2.4GHz WLAN radio and extrapolate it to higher frequencies

Summary

- Phase noise is a major obstacle for high carrier frequency communications
- Introduced advanced methods for combating phase noise in coded systems: MLSE , PSP PLL
- Develop analytical expressions for analyzing the performance of MLSE & PSP
- Analytical tools will be useful for comparing codes and designing codes more suitable for phase noise channels
- Verify analysis using a real high carrier radio system
- We plan to optimize synthesizer components based on the new mathematical tools