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CPS Paper

# An Aggregate Test for Polynomial Frequency Modulation Using Multitaper Methods

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### Presentation File

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### Brief Description

We propose a semiparametric multitaper test for the detection of modulated line components where the modulation is assumed to be created by a polynomial of degree P.

We derive an approximate distribution for this aggregated test and discuss a simulation study of its performance.

As well as comparisons to other known tests.

### Abstract

We propose a semiparametric multitaper test for the detection of modulated line components where the modulation is assumed to be created by a polynomial of degree P. This test is based on an aggregation of F-tests described in [1] that are based on the multitaper framework [2]. The multitaper method is a robust estimator for the spectral density of a time series, with significant performance gains over classical approaches such as the periodogram or direct spectral estimators. The method uses a family of orthogonal tapers, providing consistency, reducing variance and controlling broad-band bias in the estimators.

Although any arbitrary sets of weights could be used as tapers, by far the most commonly used in practice are the Discrete Prolate Spheroidal Sequences (DPSSs). These sequences are found as the solution to the problem of maximization of energy concentration in a chosen bandwidth [4]. While optimal in that sense, one downside of using DPSS tapers is the required computation time for estimating solutions when both the time series length N and the number of tapers K are large. This did not pose a problem for the F-test described in Blanchette et al. [1] but is more noticeable in our new aggregated test due to the increased computational complexity. An alternative taper scheme is sinusoidal tapers [3], which are an approximation of the minimum bias tapers of the spectral estimator, having very high computational efficiency due to their closed form. Another advantage of the sine tapers is the ability to downweight specific regions of the bandwidth: this is useful for providing a mechanism for controlling Type I error in our new aggregated test.

The aggregated polynomial F-test we propose uses multiple iterations of different sinusoidal tapers along with a weighting scheme to help control Type I error, while also reducing the total computation time that would be required if using the DPSSs. In this work, we derive an approximate distribution for this aggregated test and discuss a simulation study of its performance. In addition, comparisons of our new aggregated test against the F-tests in [1] are conducted.

References

[1] Blanchette, K., Burr, W., & Takahara, G. (2021). An F-test for polynomial frequency modulation. ICASSP, IEEE International Conference on Acoustics, Speech and Signal Processing - Proceedings, 2021-June, 5010–5014. https://doi.org/10.1109/ICASSP39728.2021.9414209

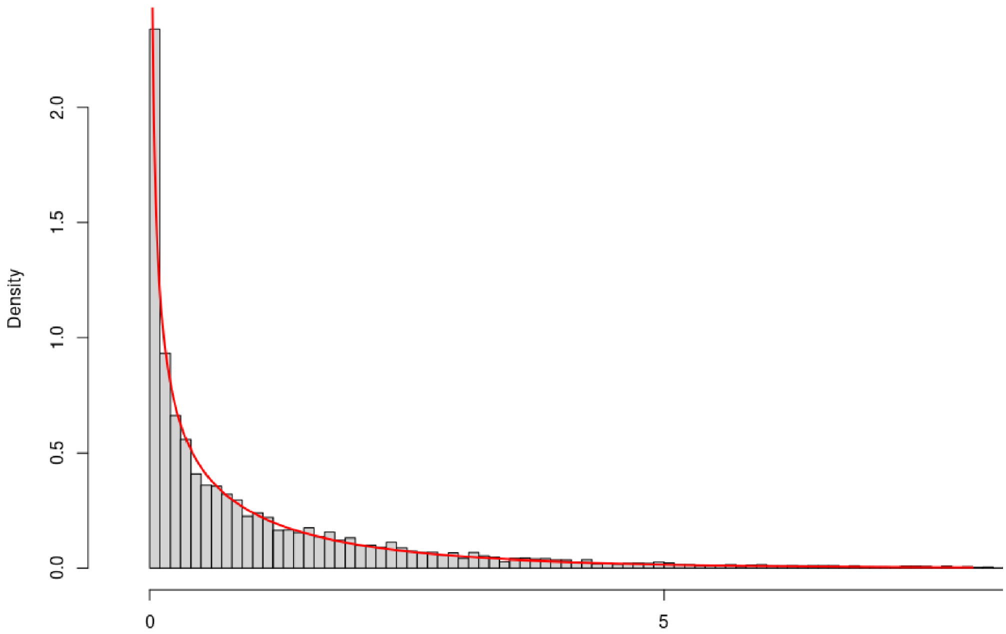
[2] Thomson, D. J. (1982). Spectrum Estimation and Harmonic Analysis. Proceedings of the IEEE, 70(9), 1055–1096. https://doi.org/10.1109/PROC.1982.12433

[3] Riedel, K. S., & Sidorenko, A. (1995). Minimum bias multiple taper spectral estimation. IEEE Transactions on Signal Processing, 43(1), 188–195. https://doi.org/10.1109/78.365298

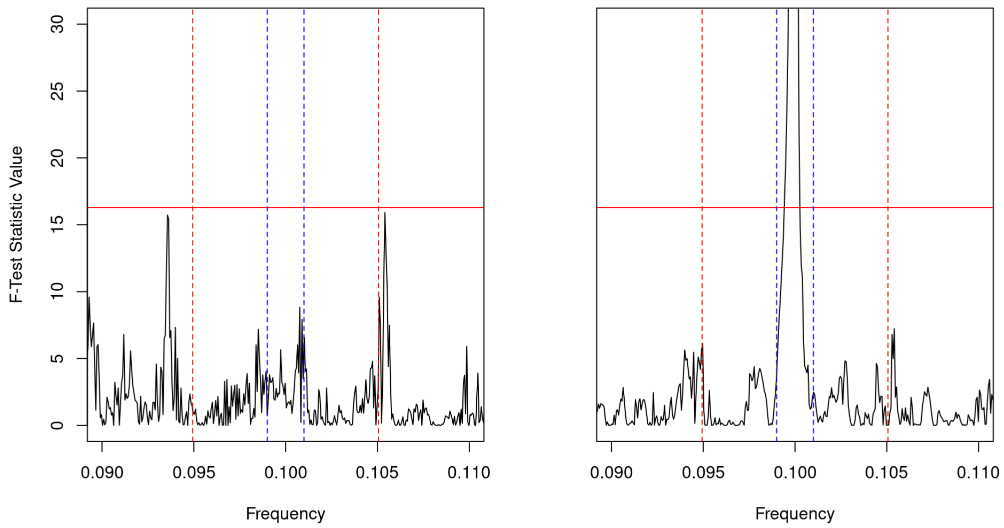
[4] Slepian, D. (1978). Prolate Spheroidal Wave Functions, Fourier Analysis, and Uncertainty—V: The Discrete Case. Bell System Technical Journal, 57(5), 1371–1430. https://doi.org/10.1002/J.1538-7305.1978.TB02104.X

## Figures/Tables

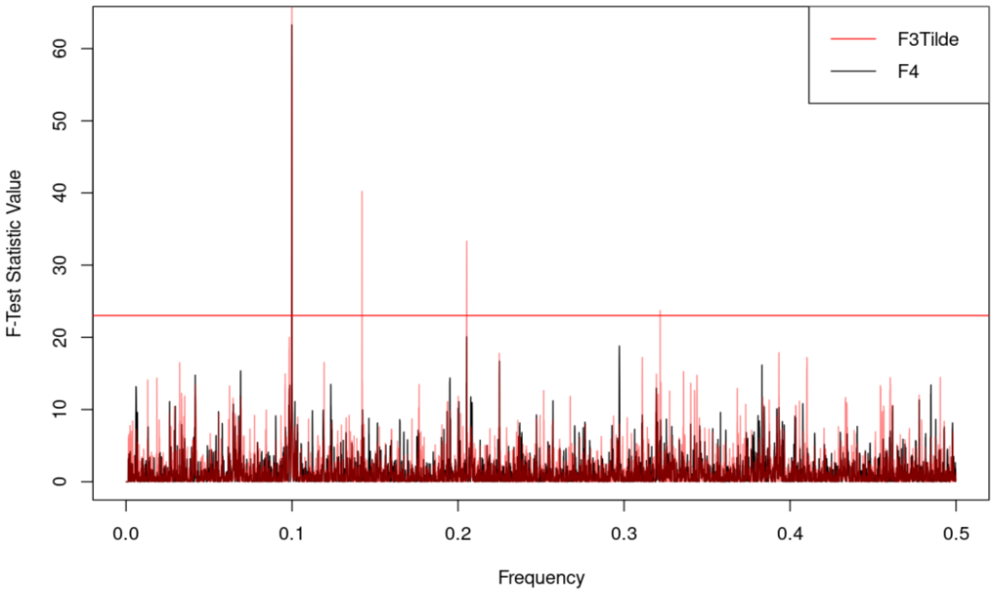
#### Density Of F4



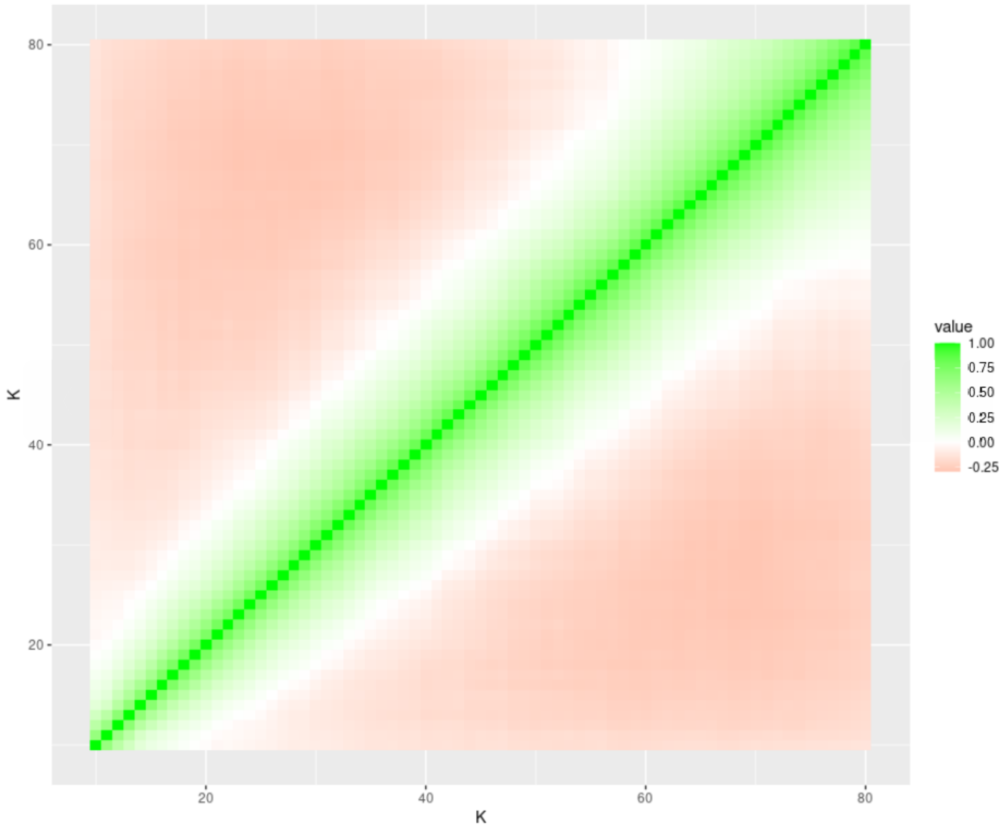
Comparison Of F3Tilde and F4



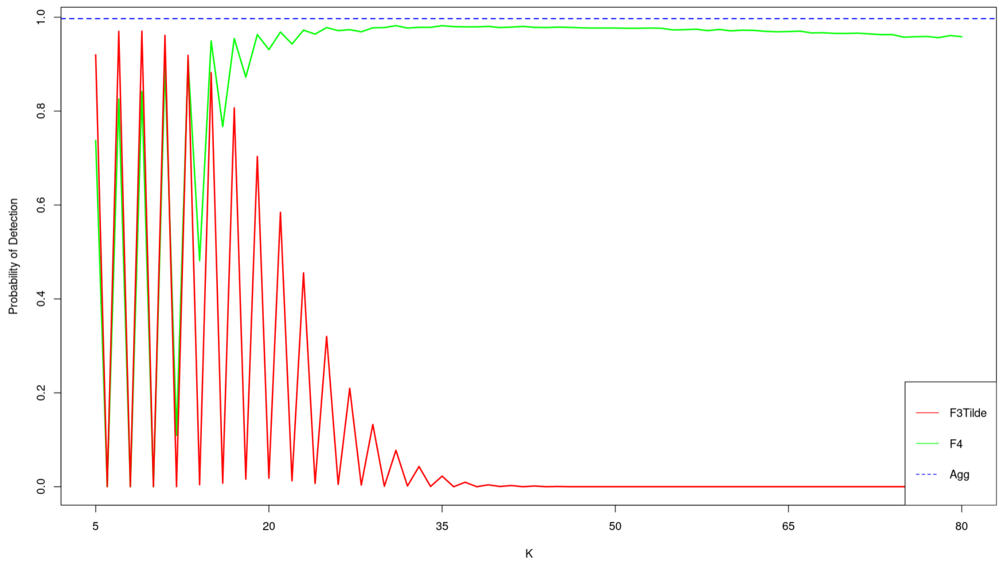
**Comparison of F3Tilde and F4 for K = 20**



**Correlation Estimate for F4**



**Probability of detection for modulation bandwidth 0.0005, comparing F3Tilde and F4**



**Probability of detection for modulation bandwidth 0.001, comparing F3Tilde and F4**