THE DEVELOPMENT OF A KALMAN FILTER CLOCK ALGORITHM

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NPL is developing a new clock algorithm to combine measurements from its three active hydrogen masers and caesium fountain clock. The algorithm takes advantage of recent developments, in particular the use of covariance reduction techniques [1]. This algorithm differs from previous Kalman filter clock algorithms in that it has been designed to operate near optimally in the presence of flicker frequency modulation (FFM). The aim of the work is to produce a composite clock that over a wide range of averaging times has near optimal stability. This is achieved by modelling the FFM approximately by a linear combination of Markov noise processes. Each Markov process is included in the Kalman filter and contributes an additional component to the state vector. Both the validity of the model and the effectiveness of adding these additional components to the state vector are examined.

To apply a Kalman filter clock algorithm to real clock data, it is first necessary to estimate the noise parameters used in the process covariance matrix. An iterative method had been developed previously [2] to resolve the magnitude of noise parameters from a measurement time series. This method is extended through the use of wavelet variances, and then applied to a “three cornered hat” of hydrogen maser measurements. Several aspects of the implementation of the algorithm are discussed, including the mechanism for adding and removing clocks, and the treatment of missing data.

The performance of the new algorithm is examined when applied to simulated measurements and also to measurements from NPL’s three hydrogen masers. The latter is achieved through comparisons against NPL’s caesium fountain clock and against external UTC timescales using two-way time transfer measurements.
