EXECUTIVE SUMMARY

This work extends earlier work derived by Overdyk and investigates the use of wavelet transform and image processing tools to estimate hopping times occurring in frequency hopping schemes. The detection algorithm identifies frequency hopping time locations found in FH schemes from the information provided by the two-dimensional short-term signal temporal correlation function(TCF).

Several operations are applied to the TCF phase to emphasize hopping time occurrences, which are contained in the TCF phase discontinuities. First, we unwrap the TCF phase and apply median filtering to the unwrapped TCF phase along the time axis t. Second, we differentiate the unwrapped TCF phase along the time axis t, and apply a second median filter to the differentiated phase along the time axis t. Next, we apply the Wavelet transform to isolate the hopping time information. Finally, we follow an image processing approach to extract the hopping time information; we first apply an edge detection algorithm to extract the TCF phase region boundaries from the wavelet transformed TCF phase. Next, we apply two erosion steps with diagonal masks, one with $+45°$ and the second one with $-45°$ orientations, to remove noisy contributions. Finally we apply the Hough transform to estimate the hopping time information and discard lines not located close enough to $\pm 45°$ orientations.

Simulations are conducted for one-hop and no-hop signal configurations with signals distorted by additive white Gaussian noise in SNR levels between -3 dB and 21dB for basic FH and pulse-shaped FH signals. Results show reliable detection performance may be obtained for SNR levels above 3 dB and good detection performance for SNR levels above 6dB for 5% to 20% detection accuracy.

Simulations show that the erosion step improves the probability of correct detection (PCD) by 12% when the SNR level is equal to 3 dB. However, the erosion operation does not result in consistent significant improvements overall.

Results show that the basic one–hop detection scheme reaches 100% accuracy for 5% tolerance level for SNR levels above 6dB. Results also show that no-hop decision results reach 100% for SNR levels above 6 dB.

Finally, results show that lower detection performances are obtained when half sine pulse-shaping is applied to the symbols. This is to be expected as pulse-shaping results in dampening the signal amplitude at both ends of a symbol, thereby making it harder to extract TCF phase discontinuities.