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Experimental Investigation of Energy Detector and Matched Filtering For Spectrum Sensing at High Frequency Band

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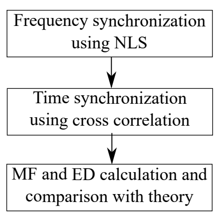
Due to the scarcity of spectrum caused by the drastic increase of wireless devices, the dynamic spectrum sharing scheme (DSS) has been proposed for efficient spectrum utilization. In DSS, users in the primary system (PS) have the priority to transmit, whereas users in the secondary system (SS) have to adaptively adjust the transmission scheme to avoid interference. Due to strict regulations, the SS are not allowed to transmit if they significantly affect the performance of PS. Therefore, a robust detector toward low SNR is needed as the SS may fail to detect the activity when the primary signals are very weak. Furthermore, as the number of wireless applications keeps rising, the move toward DSS at a higher frequency is inevitable due to the spectrum congestion at sub-6 GHz frequency bands. Although the performance evaluation of the detectors such as energy detector (ED) and matched filtering (MF) [1] has been extensively done, most of them focus on the simulation or detection at low-frequency bands, and the experimental examination at higher frequency bands is still quite limited. Since the radio propagation characteristics and the degree of phase instability from the frequency down-conversion are different, it is also necessary to experimentally clarify the performance of detectors at the high-frequency band.

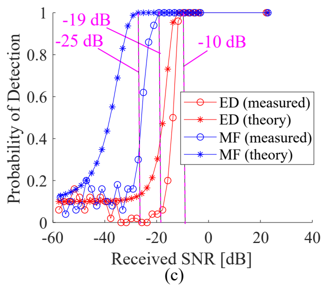
Therefore, as the preliminary study, this work investigated the detectors at 17 GHz through a direct wired connection between the spectrum generator (SG) and the spectrum analyzer (SA). Fig. 1 (a) and (b) shows the measurement parameters and data analysis flowchart. Firstly, the phase and time synchronization were achieved by using non-linear least squares [2] and cross-correlation techniques. Then, ED and MF [1] were used for the validation. Fig. 1 (c) shows the probability of detection (P_D) at 10% false alarm rate at different SNRs. The magenta lines represent the minimum SNR where $P_D = 1$ is still achieved. Due to the coherent gain, the performance of MF was significantly greater than ED. In the case of ED, the measured P_D approximately followed the theory. In contrast, the performance of the measured MF, although better than measured ED, was differed by roughly 6 dB from the theoretical values. One possible explanation is that the accuracy of cross-correlation based time synchronization degraded greatly at low SNR. Furthermore, the phase noise from the SA could reduce the coherent gain of the MF.

Parameter	Value
Center frequency	17 GHz
RBW/symbol rate	5 MHz/ 4 MHz
Sampling frequency	32 MHz
Down-sampling factor	4
Amplitude	-30 to -110 dBm
Number of samples (N)	20440 (0.64 ms)
#snapshots	50
Tx filter	Raised cosine ($\alpha = 0.5$)
Waveform info.	PN9, QPSK

(a)



(b)



(c)

Figure 1. (a) Measurement parameters, (b) Data analysis flowchart, (c) Probability of detection at 10% false alarm rate at different SNR.

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References

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