

Development of a Low Cost Compact Integrated Step Frequency Continuous Wave Radar for Non-Contact Vital Sign Detection

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There has been a tremendous need for developing low cost compact radar units for remote non-contact vital signs detection. Various types of radars have been already built including ultra wideband (UWB) radars, continuous wave (CW) radars, Frequency modulated continuous wave (FMCW) radars and step frequency continuous wave (SFCW) radars (C. Li, V. M. Lubecke, O. Boric-Lubecke, and J. Lin, IEEE Trans. Microw. Theory Techn., 61, 5, 2046-2060).

Compared with CW radars, SFCW radars have the advantages of localization and multiple subjects monitoring. Compared with UWB radars, SFCW radars are simple to build and do not require sophisticated ADC circuitries, while possessing higher signal-to-noise ratio (SNR) with long-duration waveforms. By measuring the SFCW radar in a close-loop configuration, we can readily calibrate the phase and amplitude distortion of the wide-band waveform, which may cause dispersion of high resolution range profile (HRRP). Comparatively, it requires more effort to calibrate FMCW radars. By now, SFCW radars have demonstrated capabilities in cardiac and respiratory rates detection (L. Ren, H. Wang, K. Naishadham, Q. Liu, and A. E. Fathy, IEEE IMS, 2015) and localization using compressive sensing (CS) algorithm (H. Wang, V. Dang, L. Ren, Q. Liu et al., IEEE Microw. Mag., 17, 7, 53-63).

In this paper, we will introduce portable SFCW radar realized with different layers of stack-up boards using chip components, and compare its performance with SFCW radar using connectorized components. Due to the imperfection of ADC chips, the former SFCW radar needs a RC highpass filter to remove the dc offset in the in-phase (I) and quadrature-phase (Q) channels, which converts it to an AC-coupled radar system. Both SFCW radar systems can monitor the vital signs of subjects in real-time utilizing Labview and have shown comparable performance in accuracy. The new design will be presented in detail and various validation experiments will be discussed.