VitalRFsens—A Flexible FMCW RADAR Setup

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In context of the VitalRFSens MIP, a versatile test setup has been implemented in the laboratory in order to evaluate the feasibility of vital signs sensing via RF. RF offers the potential for contactless and remote sensing of vital signs. The test setup uses a real-time Frequency-Modulated Continuous Wave (FMCW) radar based on a Vector Network Analyze, combined with signal processing running on GNU Octave / Matlab®.

This report describes a flexible FMCW radar setup, which has been implemented in the laboratory at CSEM in order to evaluate the potential to monitor vital signs (e.g., heart rate) via Radio Frequency (RF) sensing. An illustration of the setup is provided by Figure 1. The goal is to provide a real-time (RT) baseband FMCW radar signal for the purposes of development of the necessary signal processing algorithms, as well as, to make emulation of potential limitations, with respect to implementation of a future low-power Integrated Circuit (IC), easy as possible. The FMCW radar setup will allow the IC specification to be validated via signal processing of the RT signal. Importantly, the setup also serves as an evaluation platform for development of antenna and product mechanics.

An FMCW radar sweeps a transmitted tone in frequency and self-mixes it with the received signal backscattered by the environment. The farther the reflector is from the transmitter, the higher the beat frequency due to the delay between transmitted tone and the received tone. The distance is proportional to the propagation speed divided by the beat frequency. A representation of the amplitude (and phase) of the reflections versus distance is provided by taking an inverse Fourier transform (iFFT) of the received signal.

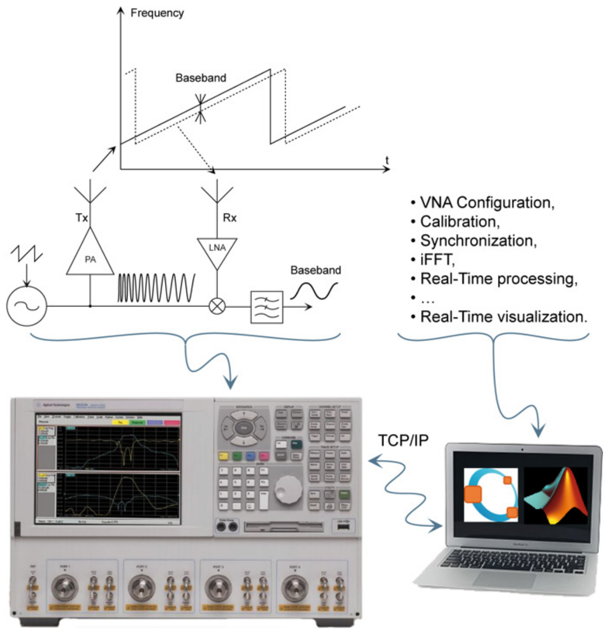

Figure 1: Setup principle.

In the setup, a Vector Network Analyser (VNA) is used to realize the RF analog processing. The remaining operation (without time-domain capability) is limited to the frequency-to-distance conversion, e.g., via an iFFT. A PC (running either Matlab® or GNU Octave) is connected to the VNA for the purposes of control and signal processing.

The flexible setup enables easy variation of the: frequency sweep (from DC to 40 GHz and, with frequency extension modules (from 50 to 75 GHz & from 75 to 110 GHz), output power, baseband bandwidth (sweep time and points per sweep) and the topology (mono-static to bi-static or even multiple Rx channel using the 4-ports). It also enables easy emulation of close-in phase noise by driving the 10 MHz frequency reference, as well as, remote signal processing and visualization.

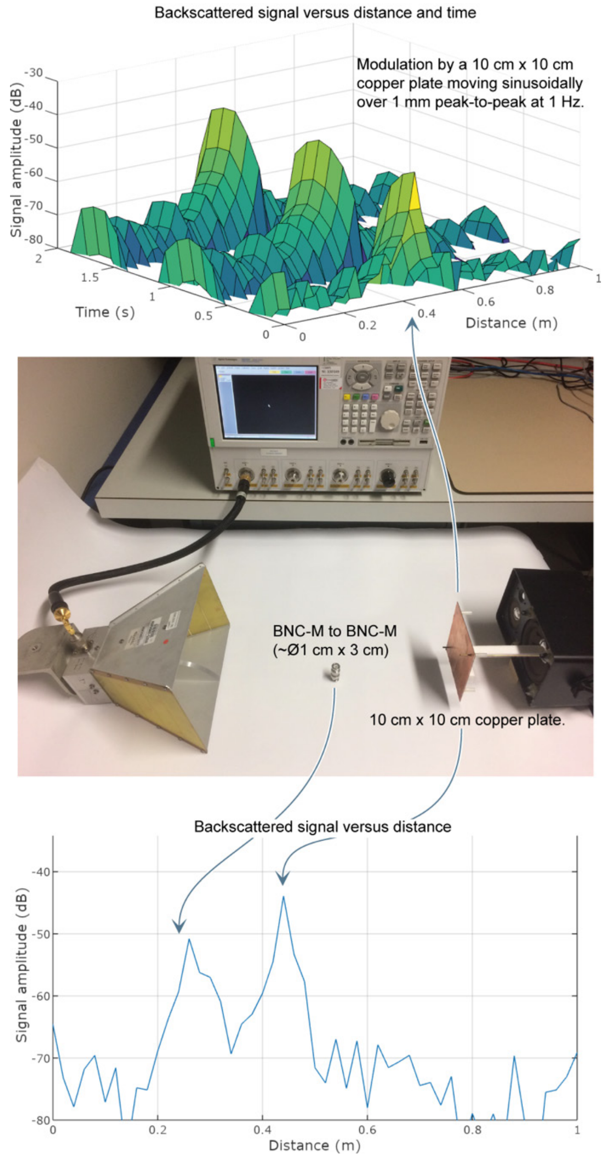

Figure 2: Real-time 10 sample/s (51 points / 10 ms sweep) running setup with 3.1-10.6 GHz (UWB) frequency sweep.

The laboratory setup, while limited in speed, is fast enough to support evaluation and development of the targeted vital signs sensing application (i.e., heart rate monitoring). In the future, the same flexible radar setup can serve as a platform for investigation and development of a variety of other applications, such as breath rate estimation, presence detection, tank level measurement and gesture recognition.