"A Software Defined Radio Interrogator for Harmonic Transponders"

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Background & Significance

Passive wireless sensors provide an opportunity for long term monitoring of remote environments. Such devices are powered only with an interrogation signal which enables them to reflect information back via a return signal. Radio Frequency Identification (RFID) systems utilize the same frequency for interrogation and return which causes unwanted interference, particularly in cluttered environments. Other devices, known as harmonic transponders (a technology currently not leveraged by NASA to the Fellow's knowledge) take advantage of non-linearities in semiconductor devices to produce a return signal that is a harmonic of the interrogation signal. This property can prove beneficial when operating in cluttered environments, since the harmonic return will not interfere with the interrogation signal. In this work, we present a compact interrogator for harmonic transponder devices.

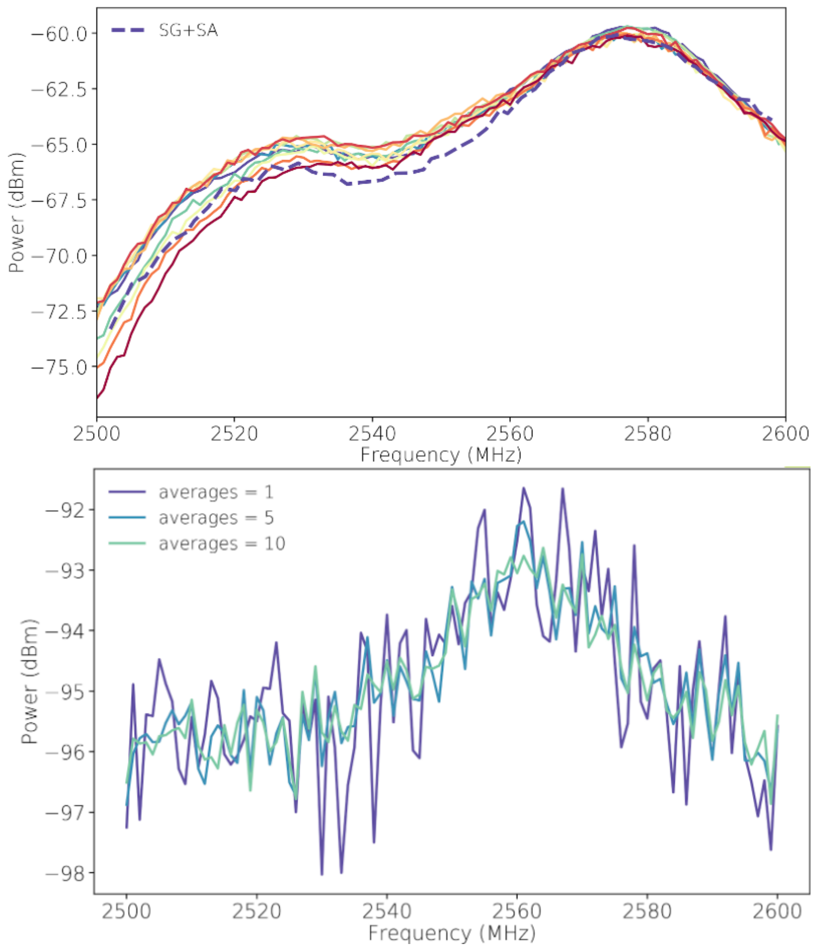
Project Goals

The motivation for this work is to develop a low-cost, compact, easily deploy-able and quick to respond interrogator that can be used with harmonic transponders. The contribution of this work is the development of a single-board software-defined radio (SDR) based interrogator that accomplishes both the interrogation (at f_1) and reading (at $2*f_1$) functions while still maintaining accurate power measurements. This single board solution shows promise for being easily integrated on a drone or similar moving platform to enable the rapid interrogation of multiple and distributed sensing devices.

Summary of Key Findings

The proposed interrogation system for the harmonic transponder presented consists of several off-the-shelf components, such as amplifiers, filters, and power splitters. The driver of the interrogator is an SDR called the BladeRF x40. The maximum instantaneous bandwidth (IBW) of the BladeRF is 28 MHZ (i.e. how much of the radio-frequency (RF) spectrum we can view in any instant), which is not sufficient to view the entire band of interest from the harmonic transponder which spans from 2.5 GHz to 2.6 GHz. However, because the center frequency of the BladeRF is easily adjusted through software, one can readily step the center frequency of both the transmit and receive ports to view the entire 50/100 MHz bands. To interface with the BladeRF, an open source software toolkit known as GNU Radio is used. GNU Radio allows all of the signal processing calculations to be carried out in real-time, which drastically reduces the time of the interrogation process. The final system was capable of performing the desired frequency sweep within 50 seconds, while maintaining accurate power measurements within 1.15 dB (compared to laboratory grade measurement equipment).

To minimize the setup, a RF PCB was designed. This was accomplished by incorporating all of the aforementioned parts (filters, amplifier, splitter) on a printed circuit board (PCB), capable of being powered by a battery. Off the shelf products were procured from various companies, resulting in a 1.25 in x 1.25 in PCB with the same filter and amplifying characteristics, meaning we can interrogate the harmonic transponder at the same distance with a much smaller setup.



Top - A series of frequency sweeps with the proposed setup vs. lab grade measurement equipment (SG+SA).
Bottom – Low power measurements with averaging used to mitigate noise. Transmit power of 1 mW.