1.0 RESEARCH PROJECT DESCRIPTION

The purpose of this research project is to develop and demonstrate the viability of wirelessly extracting measurand data from a network of surface acoustic wave (SAW) sensor devices. This sensing technique has several advantages over existing sensors. These include:

1. Wireless – no wired connections are needed to extract the data,
2. Passive – the sensors are passive and require no power,
3. Robust – the SAW sensors can withstand temperatures from 4 degrees Kelvin up to 1000 C and they can operate in the vacuum of space,
4. Inexpensive – in quantity, SAW sensor devices can be produced for tens of cents each.

1.1 System Overview

The SAW Sensor Interrogator System (S2IS) is a complete sensor and data processing system. See Figure 1. It is composed of three (3) primary elements:

1. SAW Sensor network
2. Interrogator
3. Data Processing

The SAW Sensor network is a collection of SAW tags (SAW sensor with antenna) located within range of the Interrogator unit. When interrogated, each tag responds with a return signal unique to it that also contains information about a specific item that tag is measuring, e.g. temperature, strain, pressure, etc.

The Interrogator transmits the interrogation signal, then receives and digitizes the return signals from the tags. The digitized return signals are then passed to the Data Processing element where the tag IDs and measurands are extracted and displayed. Data Processing can be integrated with or remotely located from the Interrogator.

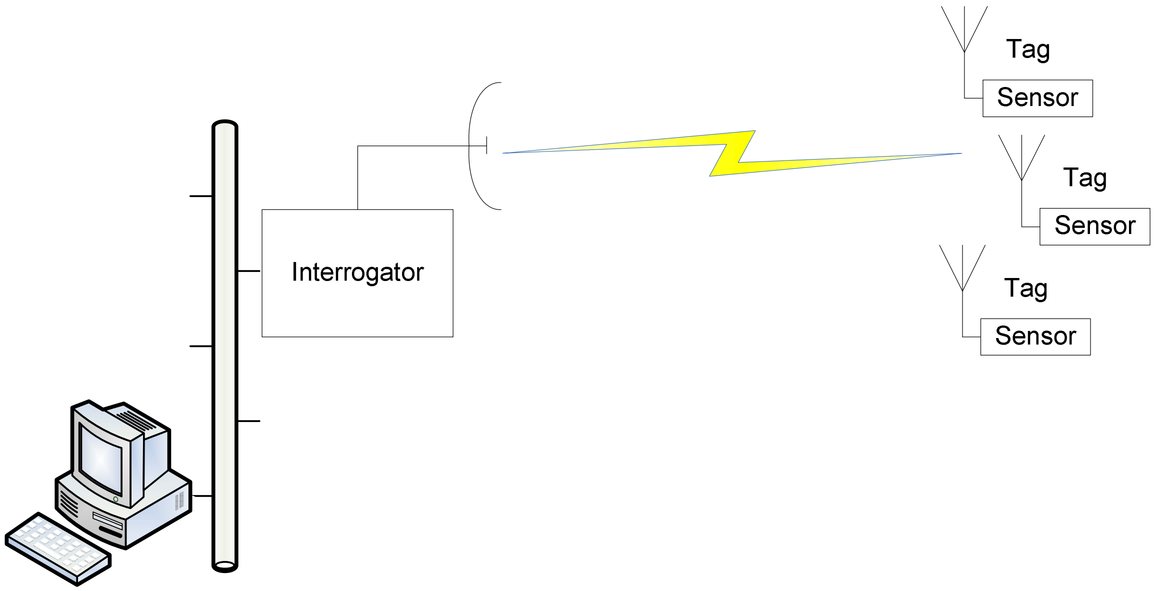

Figure 1 Prototype S2IS Concept Diagram

1.2 SAW Sensor Background

As discussed above and shown in Figure 1, the Interrogator transmits a signal to the network of SAW tags. This signal is a stepped, chirp, radio frequency (RF) pulse as shown in Figure 2.

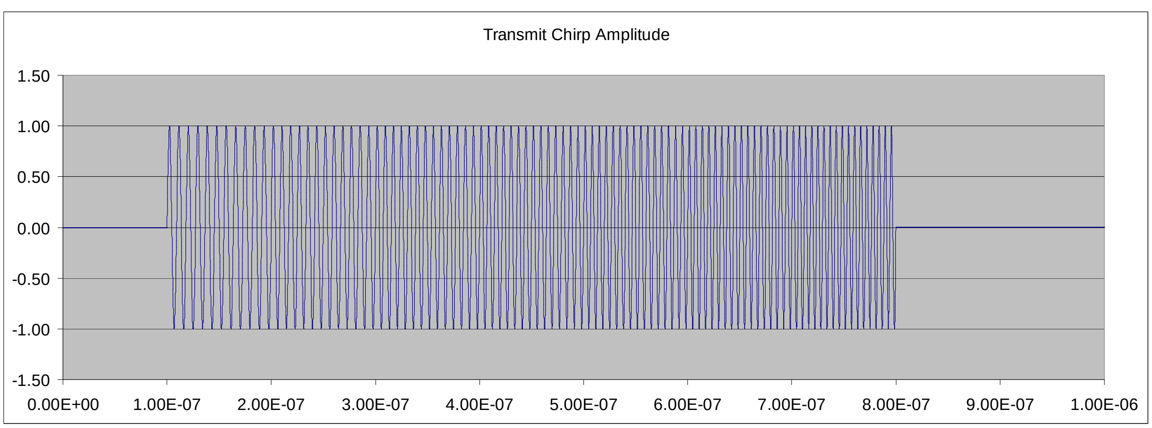

Figure 2 Tx Upchirp Signal

The pulse is received by an antenna connected to the central transducer of each SAW sensor. See Figure 3. This transducer radiates power equally in both directions, sending a pulse to the left and to the right reflector banks.

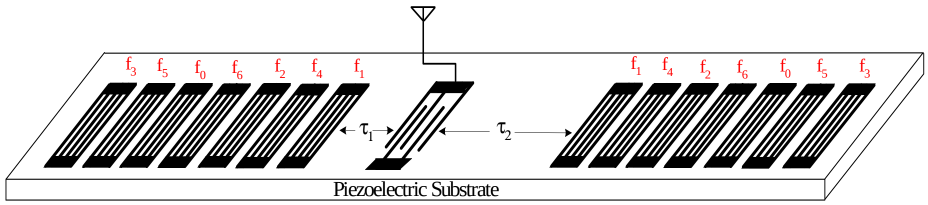

Figure 3 Wireless, Passive SAW Sensor

Both reflector banks are composed of individual reflectors, each tuned to a different frequency. The individual frequencies of the transmit chirp signal reflect from their associated reflectors and are returned to the central transducer for transmission back to the Interrogator.

Because the two reflector banks are at different distances (τ_1 and τ_2) from the central transducer, the two reflected pulses do not recombine into a single pulse, but are re-radiated as two separate pulses. See Figure 4.

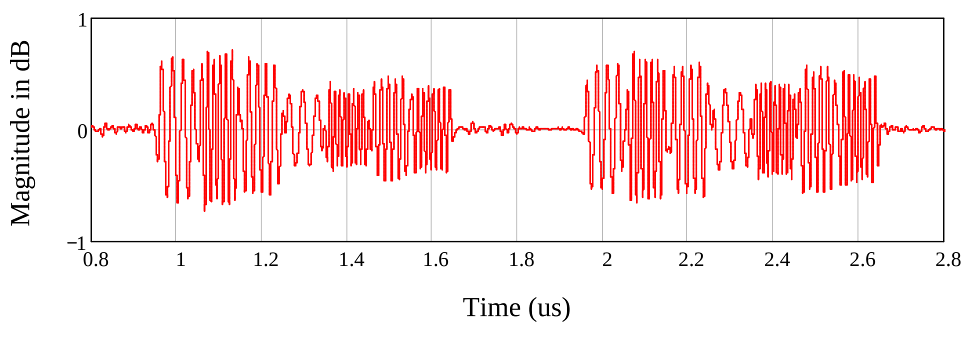

Figure 4 RF Return Pulses

When the piezoelectric, SAW substrate is put under stress by temperature, pressure, etc. the velocity of propagation changes and so does the time between the two return pulses. By measuring the change in time separation from the design value, the temperature, pressure, or whatever is stressing the substrate can be determined.

Figure 3 and Figure 4 also illustrate another aspect of these SAW sensors that is critical for their use in sensor networks. If two different SAW sensors have the seven individual reflectors that make up each reflector bank arranged in different orders, then the return signal from each sensor will be in a different frequency order. This provides a mechanism for uniquely identifying an individual SAW sensor and allows the sensor to be networked. This technique is referred to as Orthogonal Frequency Coding (OFC) and was pioneered at the University of Central Florida (UCF). Figure 4 shows the return signal pair and it can be seen that the frequency order of the input signal has been re-arranged.

In addition, this type of sensor can be used for gas, and possibly, chemical sensing. For example, if a thin film of palladium is applied to the surface of the SAW device between the central transducer and right-hand reflector bank, then a hydrogen gas sensor can be built. The palladium responds to the presence of the hydrogen, which changes the propagation characteristics of the right-hand pulse. Again, this changes the delay between the two return pulses.

2.0 NECESSARY COMMUNICATIONS FACILITIES

Transmission of the chirp signal is necessary for demonstration of the technology in a network of sensors. For a single sensor, only a single frequency pulse would need to be transmitted and the two return pulses correlated. However, in a multiple sensor network, a single frequency pulse would not allow the return pulses from the different sensors to be separated out. Multiple transmit frequencies allow each sensor to configure the return pulses to be unique for that sensor. This would allow the sensors to be networked.

3.0 EXISTING COMMUNICATIONS FACILITIES

There are currently no known communications facilities that can be utilized for the transmission of the chirp signal and the reception and processing of the return pulses.