RF SAW, Inc.
SAW RFID READER System Model 501

Operational Description

The SAW RFID Reader System Model 501 and the RF SAW, Inc. family of Global SAW Tag (GST) products are the key elements of a new Radio Frequency Identification (RFID) system that is characterized by low power operation and high read range. Surface Acoustic Wave (SAW) devices are widely used in many products such as cell phones and other mass market products. SAWs have also been used as tag devices in commercial systems but until recently, their widespread use was not possible due to the limited number of unique codes that could be produced in these devices. The invention of the Global SAW Tag now makes it possible to encode SAW devices with data capacities of more than 128 bits. The SAW RFID Reader System Model 501 is designed to be a compact and cost effective reader for the GST family of RFID tags.

To understand the operation of the system, it is important to review the operation of SAW devices as they are applied to tag applications.

SAW-based RFID Technology

As shown in Figure 1, the operating principle of a SAW RFID tag is based on converting an interrogating radio wave from the reader directly into a nano-scale surface acoustic wave on the SAW chip surface. The tag's antenna is directly connected to the IDT (interdigital transducer) which uses the piezoelectric effect in the lithium niobate substrate material to efficiently convert between radio waves and surface acoustic waves. That acoustic wave then travels past an encoded set of wave reflectors which interact to produce a unique acoustic wave pulse train. These pulses are directly converted into an encoded radio wave reply signal that is sent back to the reader.

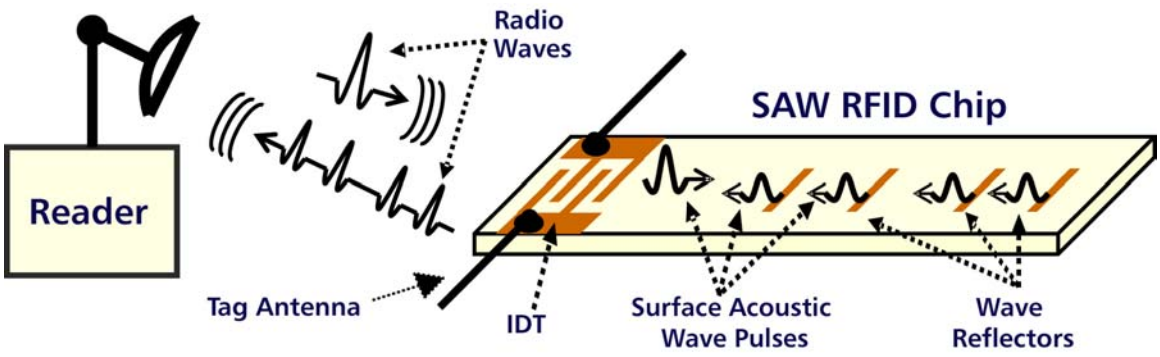

Figure 1 - SAW RFID Operation: The reader emits a radio wave pulse that is directly converted into a nanoscale Surface Acoustic Wave on the SAW chip surface by the "IDT" (interdigital transducer). That acoustic wave travels past a set of wave reflectors to produce uniquely encoded acoustic wave pulses, which travel back to the IDT. The IDT converts those pulses into an encoded radio wave reply signal that is sent back to the reader. The SAW chip operates using the piezoelectric effect and does not require DC power. (Note: chip size is not to scale.)

SAW RFID systems are in use today in heavy manufacturing environments. Previously, these applications were limited to tags with an address range of 14 bits or less. The recent GST breakthrough by RF SAW, Inc. enabled the development of an encoding algorithm and manufacturing process capable of producing tags with more than 128 bits of address space. The GST has sufficient data capacity to comply with EPC encoding and similar global RFID requirements, which means that SAW-based RFID is now a main-stream high-volume RFID technology.

The new encoding algorithm uses a limited number of reflectors that encode data using combinations of pulse time and pulse phase. For example, 16 bits of data can be encoded with only four pulses spread across 75 tightly spaced time slots. Six such groups of reflectors provide 96 bits of address space. Additional groups of overhead data are added for synchronization, error checking, and simultaneous detection of multiple tags (anti-collision).

A key feature of SAW RFID tags is that they do not use any DC power source. SAW tags are truly passive devices that operate at any signal level (even very low) as long as the reply signal received at the reader is sufficient to detect the data. In high-speed, long-read-range applications, the minimum signal required at the tag is a fraction of a microwatt. The signal required is even lower in less demanding situations. Because of this physical characteristic, SAW RFID readers can use very low transmit power.

Model 501 SAW RFID Reader System

The Model 501 SAW RFID Reader System operates in the 2.4 to 2.483 GHz ISM band and can be used in a wide variety of industrial applications. The major components of the system are the reader, an external power supply that powers the reader, cables to connect the reader to the antenna system, and a variety of antenna system configurations that allow the system to be tailored to specific RFID application. Cabling is also required to connect the reader to a host computer. A typical system is shown in Figure 2.

Figure 2 - Typical RF SAW, Inc. Model 501 SAW RFID Reader System

Reading of a SAW device can be accomplished with a reader having a wide variety of signal structures. This is possible because the SAW device itself is a linear device. Therefore, the signal that is received by the SAW tag is retransmitted with delays that are determined by the encoding pattern on the surface of the SAW device itself. One of the methods of reading the tag is to send a short pulse of RF energy to the tag as described previously. Another method, often more efficient than the short pulse, uses a swept RF signal in a technique that is known as FM CW. This technique has been used in radar systems for many years. This technique minimizes the amount of transmit signal required for RFID operation and is the technique used in the Model 501 SAW RFID Reader System. With this technique, the transmitter sweeps across a relatively wide band of frequencies. Signals received by the receiver from the tag device are mixed with the sweeping transmit signal producing tones that correspond to the delay of the returned signals. Measuring the frequency and

amplitude of these tones allows the delay pattern of a SAW device and its encoding to be determined by the reader.

In most applications, transmitting the signal to the tag and receiving the returned signal is done with a single antenna similar to the operation of a radar system. The size and gain of the antenna is determined by the read range and directivity that is required to implement a specific RFID application. In some RFID applications, the reading environment has a considerable amount of signal attenuation or reflection from the objects being read. A significant improvement in reading performance can be achieved by using a separate antenna that is devoted primarily to transmitting the RF signal and a second antenna that is used primarily to receive the returned tag signal. This configuration allows reading through the objects instead of the radar mode described above. The two antenna configuration of the Model 501 SAW RFID Reader System is implemented with a microwave circulator that is connected to the RF port of the reader and the two antennas. This configuration is also useful in applications where there are strong signal reflections or interference in the reading environment.

To complete the reading function, data from the reader is fed to a host computer via an RS-485 port. The computer maps the decoded tag information to specific objects or items that are being identified with the RFID system.