The Global SAW Tag - a New Technical Approach to RFID

900 Alpha Drive, Suite 400
Richardson, Texas 75081
www.rfsaw.com

 # RFS-1465

Introduction

Surface Acoustic Wave (SAW) devices are key components in many radio frequency (RF) applications. SAW devices are widely used in high volume, cost sensitive applications such as cell phones, color televisions, VCRs, garage door openers, and automobile smart keys. RFSAW, Inc., a leader in precision SAW technology, has invented a new class of SAW RFID devices, the Global SAW Tag (GST). The GST is a major advance in passive RFID and is an exciting alternative to IC-based RFID. The majority of the exploding RFID markets require passive (i.e. no battery) tags. SAW RFID uses fundamentally different physical principles than other passive RFID technologies, resulting in numerous sustainable competitive advantages.

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.

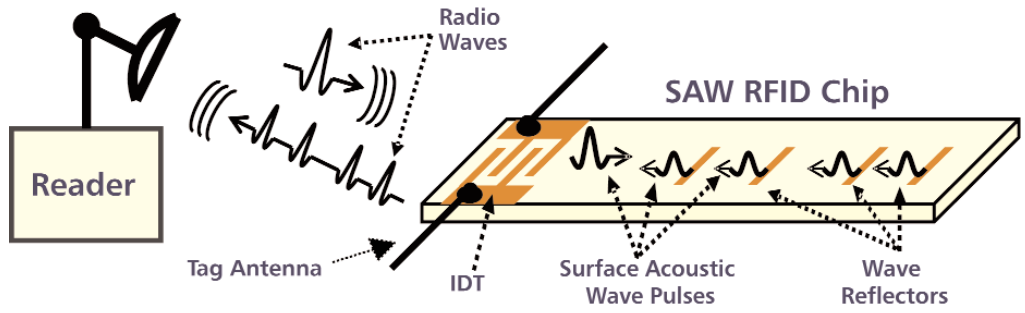

Figure 1 - SAW RFID Operation: The reader emits a radio wave pulse that is directly converted into a nano-scale Surface Acoustic Wave on the SAW chip surface by the "IDT" (interdigital transducer). That acoustic wave travels past a set of wave reflectors to produce uniquely encoded acoustic wave pulses, 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 RFSAW 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 often use very low transmit power.

IC-based RFID Technology

IC-based RFID tags use semiconductor physics in an integrated circuit (IC) to receive, detect, decode and generate responses to an RFID reader interrogation signal. As shown in **Figure 2**, the passive IC tag chip contains communications, powering and computing functions. Tags and readers communicate using a data protocol that is specific to the tag's design. Data is sent from the reader to the tag by a small modulation of the powering signal. Reply data is sent from the tag to the reader by modulating the backscatter signal.

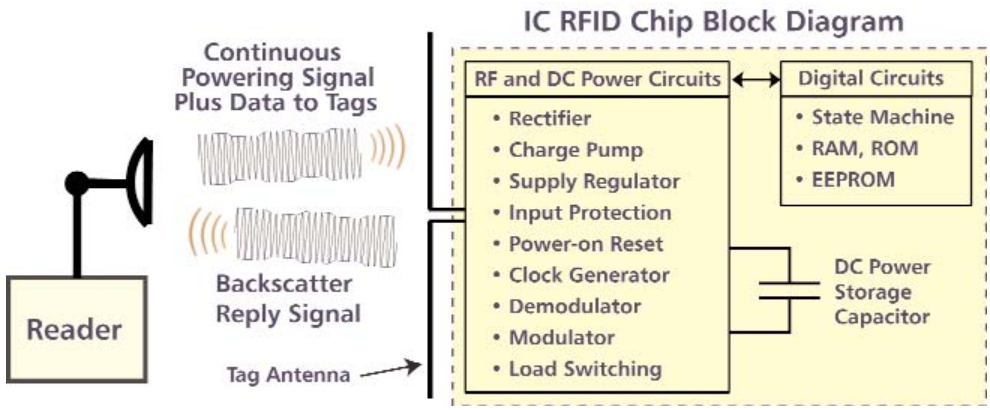

Figure 2 - IC RFID Operation: The reader emits a continuous high level powering signal to the tag. The signal is received by the tag antenna and is connected to an input rectifier in the IC chip to convert the signal to DC for storage in the capacitor and ultimately to power the chip. Reading of the tag can be achieved using a multi-step predetermined protocol only if adequate DC power is maintained throughout the entire interrogation cycle.

A key element of a passive IC tag operation is that it must have a DC power source. A rectifier circuit followed by a charge pump circuit is used to extract DC power from the reader's transmitted signal. To allow DC power extraction, the level of the signal available from the tag antenna must reach a critical threshold level of approximately 100 microwatts and must be maintained at that level throughout the process of reading all the tags in the read field. This approach requires a high power reader signal to deliver adequate energy to the tags. The powering signal is easily interrupted and/or attenuated below the critical threshold level in real world reading environments. This further restricts read range and overall reliability. The large powering signal also creates significant radio interference and creates worldwide regulatory issues.

Global SAW Tag Competitive Advantages

The GST has numerous advantages over passive IC tags because it uses fundamentally different physical operating principles.

- A SAW tag operates successfully with short bursts of signal, while an IC-based RFID tag requires a large uninterrupted signal from the reader to power the tag.

- The GST operates with low reader power in the 2.45 GHz ISM band that allows GST tags to be compliant with RF emission regulations throughout the world.

- The low power required by GST tags results in longer read distances and greater penetration into pallets loaded with metal or liquid items. This latter advantage enables GST reader systems to read interior items of a pallet as opposed to merely the items on the corners and edges of a pallet.

- GST readers use low power spread spectrum signaling that provides high-speed accurate reading and allows tag readers to have substantially higher interference resistance and spectrum compatibility with other systems and/or RFID readers.

- The reading process for the Global SAW Tag inherently recovers the arrival time of a returning signal. Determining the time of arrival directly provides information pertaining to the distance between the reader and the tag. This information can be used to determine speed, direction of motion, and to discriminate between tags located in adjacent spaces such as dock doors, conveyors, and checkout lines.

- The reading process for the Global SAW Tag also recovers the phase shift of a returning signal. Recovery of the phase shift between the transmitted signal and the received signal provides a direct measure of the temperature of the tag.

- SAW tags are difficult to counterfeit because their unique ID number is programmed at the factory. Also, this "ID number only" approach implements the low-cost EPC vision where data is stored on a secure networked data base and not in the tag.

- Because a SAW device consists only of a piezoelectric crystal and a single layer metal pattern, SAW tags are very robust when subjected to harsh environments. A SAW tag can withstand gamma ray sterilization and elevated operating temperatures. In contrast, IC-based tags are very sensitive to such harsh conditions.

In large production volumes, a SAW-based RFID system is lower in cost than competing systems. First, the SAW tag uses an inherently lower cost chip. Secondly, it does not require an interposer strap to connect the chip to the tag antenna. Thirdly, the tag antenna for 2.45 GHz is much smaller and less costly than tag antennas for competing IC-based RFID. Additional savings in overall system cost result from placing key signal processing functions like anti-collision and error-detection in the reader unit instead of the tag.

Summary

RFSAW, Inc. is using a fundamentally new technical approach to provide superior RFID solutions. The Global SAW Tag is the only viable RFID solution in many applications, especially those where extended read range, reading tags on metal and liquid items, reading tags in harsh environments, and where international tag mobility are important. The GST is a powerful new addition to the field of passive RFID that significantly expands the size of the RFID market by providing viable solutions for both new and existing RFID applications.