One Tag Worldwide!

SAW RFID READER SYSTEM
Model 501

USER'S MANUAL

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Notices

Changes or modifications to this device not expressly approved by the manufacturer could void the user's authority to operate the equipment.

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that required for successful communication

The installer of the radio equipment must ensure that the antenna is located or pointed such that it does not emit RF field in excess of the Health Canada limits for the general population; consult Safety Code 6 obtainable from Health Canada's website www.hc-sc.gc.ca/rpb.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operate in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and , if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operations of the equipment in a residential area is likely to cause harmful interference in which case the user will required to correct the interference at his own expense.

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Limited Warranty

RF SAW, Inc. warrants its products to the original purchaser to be free of material or workmanship defects for a period of 90 days from date of purchase. RF SAW, Inc. will repair or replace the defective product at their discretion.

The information in this document is subject to change without notice.

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SECTION 1 – INTRODUCTION

1.1 Product Description

The Model 501 SAW RFID Reader System incorporates patented radio frequency identification technology to provide a compact, low power, RFID solution utilizing Surface Acoustic Wave (SAW) technology to achieve superior performance in passive–tag RFID.

The Model 501 SAW RFID Reader System supports global 2.45 GHz operation, and offers superior long–range reading capability with high–speed and accuracy over a wide temperature range. The system provides a wide range of antenna configurations and data capacities in the tag devices to match the specific needs of an RFID application.

1.2 System Technology

The Global SAW Tag (GST) is a breakthrough application of the proven SAW technology that is widely used in cell phones and other mass market products.

Surface Acoustic Wave (SAW) tags are truly passive devices in which the piezoelectric effect allows direct RF interrogation of an encoded, sub–micron reflector pattern without external power. SAW tags avoid the inherent performance limitations of IC chip–based products that must obtain DC power from large continuous RF reader signals. Thus, SAW RFID tags read robustly even if reader signal strength is low or is temporarily interrupted (as often happens in the real world). This translates into superior read range and signal penetration.

In addition, SAW tags use interference–resistant broadband signals. A SAW tag reader is inherently capable of determining the tag's range, speed, direction of travel and temperature.

RF SAW, Inc's family of SAW tags, readers, and antennas allow flexible systems to be customized for a wide range of military, industrial and commercial applications. The inherent advantages of GST technology offer users the preferred RFID solution.

1.3 System Features

- Worldwide 2.45 GHz tags
- More than 128 bits of address space
- 96- and 64-bit tags: EPC alternative technology compatible
- Compact, low power reader
- High performance GST tags

- Solution for difficult reading environments (liquids and metals)
- Superior read range
- Robust anti–collision
- High speed, accurate reading
- Interference resistant

1.4 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.

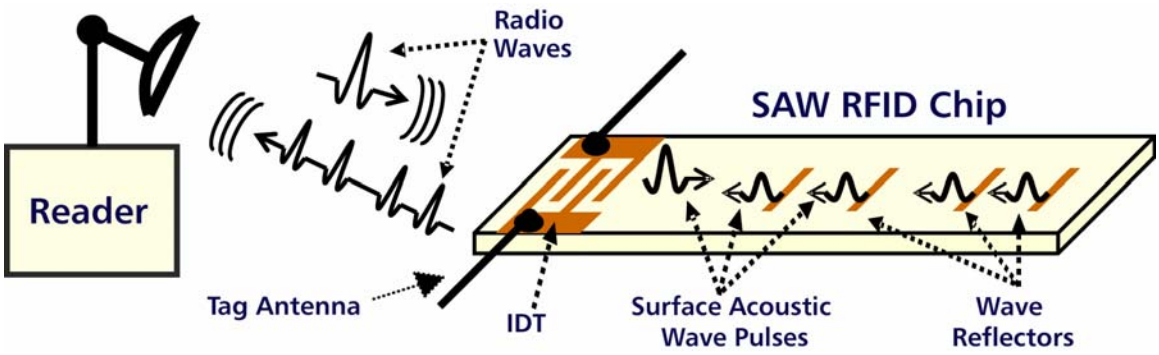

Figure 1 - SAW RFID Operation: The reader emits a radio wave pulse that is directly converted into a nanoscale Surface Acoustic Wave on the SAW chip surface by the "IDT" (interdigital transducer). That acoustic wave travels past a set of wave reflectors to produce uniquely encoded acoustic wave pulses,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

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.

1.5 System Components

System Item	Description	RF SAW P/N
READER		
	Model 501 SAW RFID Reader	411-0001-001
CABLE ASSEMBLIES		
	Single antenna: 20-ft RG223	412-0001-001
	Dual antennas: 2 20-ft RG223	412-0001-001
	1-ft RG223	412-0002-001
	1 Circulator	412-0003-001
ANTENNA ASSEMBLIES		
	9 dB gain LCP polarized-HS	414-0001-001
	12 dB gain linear polarized-HS	414-0002-001
	15 dB gain LCP polarized-HS	414-0003-001
	15 dB gain linear polarized-HS	414-0004-001
	17 dB gain LCP polarized - HS	414-0005-001
	17 dB gain linear polarized-HS	414-0006-001
	18 dB gain LCP polarized-HS	414-0007-001
	18 dB gain linear polarized-HS	414-0008-001
	8 dB gain LCP polarized-HLT	414-0009-001
	8 dB gain linear polarized-HLT	414-0010-001
	14 dB gain linear polarized-HLT	414-0011-001
	15 dB gain linear polarized-HLT	414-0012-001
	18 dB gain linear polarized-HLT	414-0013-001
	18 dB gain linear polarized-MR	414-0014-001
	24 dB gain linear polarized-A	414-0015-001
POWER SUPPLY		
	120VAC input, 24VDC output	413-0001-001
MANUAL		
	User's Manual	415-0001-001

WARNING

Any changes or modifications to the Model 501 SAW RFID System equipment that are not expressly approved and/or supplied by RF SAW, Inc. could void the user's authority to operate the equipment.

This device has been designed to operate with an antenna having a maximum gain of 24 dB. Antenna having a higher gain is strictly prohibited per regulations of Industry Canada. The required impedance is 50 ohms.

SECTION 2 – SPECIFICATIONS

2.1 System

PARAMETER	DESCRIPTION
Tag Element	Surface Acoustic Wave (SAW) piezoelectric crystal device
Reader	2.4 GHz ISM band reader
Reader Antennas	Conventional flat panels (linear and circular polarization) and parabolas
Read Range	up to 10 meters (depends on system components)
Anti-collision	Spatial, and code division implementation
EM Compatibility	Adaptive interference filtering

2.2 Reader

PARAMETER	DESCRIPTION
Frequency Range	2.4 - 2.483 GHz
RF Field Strength	50 millivolts per meter maximum (measured at 3 meters from antenna)
RF Port	RF – Single Tx/Rx
Data Ports	RS-485, DB9 connecter
Tag Read Speed	1000 per second - data collection
Dimensions	9.1" x 6.6" x 2.1" (23.1 cm x 16.8 cm x 5.3 cm)
Weight	2.5 lbs
Power Requirements	18-72 volts DC; 6 watts maximum
Temperature	Operating -20° to +50° C
FCC ID	SHT005010

2.3 Serial Communication Interface

Electrical Interface Specification

Parameter	Description
Signal Format	RS-485
Baud Rate	115200 b/s
Data Bits	8
Parity	None
Stop Bits	1
Hardware Flow Control	None
Maximum Cable Length	>1000 ft

Mechanical Interface Specification

Parameter	Description
Connector Type	DB 9F
Locking Screws	4-40 NF Standoff
Mating Connector	DB 9M

Pin Number Assignments

Pin	Signal Name
1	T+
2	T-
3	R+
4	R-

SECTION 3 – INSTALLATION

3.1 General Installation

a) Unpack the reader system and verify that the reader, antenna(s), RF cable(s) and power supply are present and that no physical damage has occurred during shipment. If items are damaged, contact RF SAW, Inc. to obtain replacement items.

b) Determine the best layout for the major system components. Antennas must be located within 20 feet of the reader (length of the RF SAW, Inc. supplied cable P/N 412-0001-001 is 20 feet) and within the read range of the tagged object to be read. The reader should be located in a dry, secure location, near a source of power and accessible to data connections. If a data cable has been provided by RF SAW, Inc., verify that it is present and that no physical damage has occurred during shipment. If the data cable is being provided by the user, verify that the connections are correct by comparing the cable pin assignments to the Specifications Section of this document.

Note: The antennas used with the Model 501 SAW RFID Reader System are very directional and proper placement and alignment of the antenna(s) is needed to achieve the proper tag reading performance of the system.

3.2 Single Antenna Installation

a) Once the reading location has been determined, refer to the instructions supplied with the antenna to mechanically mount the antenna. A common method for mounting the antenna is to clamp the antenna mounting bracket to a metal pipe or similar rigid support that is secured to the floor or other support structure.

b) Connect the RF cable to the antenna and torque the connector to 8 inch pounds. Secure the cable to avoid physical damage to the cable during normal operation. Avoid kinks and sharp bends (less than 2" bend radius) along the cable as this may damage the cable.

3.3 Dual Antenna Installations

a) Dual antenna configurations are recommended when it is desired to read tags by reading through the tagged objects or at an angle rather than reading from one side. If the RF attenuation of the tagged objects is high, reading performance is improved by mounting the two antennas

such that they are facing each other or at an angle such that the two antenna patterns intersect at the tag location on the object.

b) Dual antenna systems make use of a microwave circulator to direct most of the transmit RF power to one antenna and to direct the received signal to the reader from the other antenna. The antennas are connected to the circulator using two of the 20 foot cables (P/N 412-0001-001). In installations where potential sources of RF interference are known to exist, the interference can often be minimized or eliminated by purposely selecting the positions of the transmitting and receiving antennas. The transmit, receive and reader ports are labeled on the circulator.

Note: Damage can result to the circulator by subjecting the device to high magnetic fields. Avoid installing the circulator near strong magnets or other sources of magnetic fields.

c) Connect the RF cables to the antennas and the circulator. Torque the connector to 8 inch pounds. Secure the cable to avoid physical damage to the cable during normal operation. Avoid kinks and sharp bends (less than 2" bend radius) along the cable as this may damage the cable.

3.4 Reader Installation

a) Mount the reader on a shelf or suitable bracket. Connect the antenna to the antenna port on the reader and torque the connectors to 8 inch pounds. See Figure 3. Connect the host computer to the reader using the RS-485 connection on Com Port 1. See Figure 4. If the host computer does not have an RS-485 interface, install an RS-485 to RS-232 adapter following the instructions supplied with the adapter. When long data cables are used (> 15 feet), it is recommended to locate the RS-485 adapter at the host computer end of the data cable. A twenty foot cable with an adapter is available from RF SAW, Inc. and longer cables can be special ordered. Pin number assignments and electrical interface specifications can be found in Section 2.3 of this manual.

b) Connect the power supply to the reader using the connector on the front face of the reader. See Figure 4. Plug the power supply into a 120 volt ac outlet and verify that the green Power LED on the unit is illuminated.

c) Install the reader interface software on the host computer and start the software using the user instructions supplied with the software.

d) Test the system by placing a tag in the read field and verifying that the tag is read successfully.

Figure 3 – Reader Rear Panel Showing Antenna Connection

Figure 4 – Reader Front Panel Showing Power and Data Connections

SECTION 4 - TROUBLESHOOTING

Problem	Probable Causes	Corrective Action
Power LED does not light	Power supply is not connected to reader	Check plug on front panel of reader
	No AC power supplied to Power Supply	Check AC voltage to outlet
	Power Supply is defective	Replace Power Supply
Reader will not read tags	Antenna is not connected to reader	Check cabling at antenna and on reader antenna port
	Cable to antenna is defective	Visually inspect cable and check for continuity with VOM. Replace if defective with P/N 412-0001-001 rev A
	Antenna is defective	Visually inspect antenna. If defective, replace with identical P/N from RF SAW, Inc.
	Tag is defective	Try reading known good tags
Reader will not communicate with host computer	Communication cables not connected properly	Visually inspect cable connections and correct if needed
	Communication parameters are set incorrectly on host computer	Check parameters in Section 2.3 of this Manual and correct if necessary
Degradation in read range	Interference from other 2.4 GHz devices	Identify source of interference and eliminate from reader input

SECTION 5 – ACRONYMS and ABBREVIATIONS

ACRONYM	DEFINITION
EM	Electromagnetic
EPC	Electronic Product Code
ERP	Effective Radiated Power
FM CW	Frequency Modulated Continuous Wave
GST	Global SAW Tags
IC	Integrated Circuit
ISM band	Industrial Scientific and Medical frequency band
RF	Radio Frequency
RFID	Radio Frequency IDentification
SAW	Surface Acoustic Wave

SECTION 6 - CONTACT US

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