TEXAS INSTRUMENTS

TIRIS™ RADIO FREQUENCY IDENTIFICATION SOLUTIONS

TIRIS AUTOMATIC RECOGNITION OF CONSUMERS: SERIES 5000 READER SYSTEM

ARC-2-1999

Brief Overview of the System

The TIRIS RFID system for automatic consumer recognition consists of keyring tags, vehicle tags and RF reader electronics. This system is custom-designed for the outdoor drive through environment. The design is based on a patented dual-frequency approach that draws from TI's core competencies of traditional low frequency TIRIS applications and higher frequency RFID systems engineered for electronic toll collection. Each tag contains a unique and secure ID code that is programmed in at manufacture. In the application, each customer is individually registered to a tag so that he can be uniquely identified.

The tags communicate with the RF reader unit. After a tag enters the read zone and the reader receives the ID code, the system begins an authentication process to verify that the tag is genuine. It also performs a lookup in the customer database to find the credit card type and number that the customer has assigned to the tag, and then sends a request for authorization to the credit card company. The authentication and authorization processes can be completed within a few seconds.

Each customer is individually registered to a tag so that he can be uniquely identified.

In the retail fueling application, the reader is normally located within the fuel dispenser. Most dispensers have four antennas, two on each side of the dispenser. The antenna for the keyring tag is located behind the face of the dispenser; easily accessible to the consumer. The antenna for the vehicle tag is mounted on top of the dispenser. This antenna creates a read zone in which the vehicle tags are accurately read.

Choose from two options: vehicle mounted or keyring tag.

Two Types of Tags

Tags are available in two forms. The keyring tag is small enough to be attached to a keyring. The vehicle tag is mounted inside the back window of a vehicle.

Each TIRIS tag contains a unique ID code that can be associated with a record in a central database for managing transactions. This code is programmed during manufacture and can never be changed.

The tags provide storage space to program customer-specific information, for example, to support fleet operations data, or to store customer preferences.

The reader captures the data of the tag wirelessly and automatically. There is no need to key in any information, thus eliminating human errors. The data communication between the tag and the reader is protected by a powerful 16-bit cyclic redundancy check algorithm (CRC-CCITT).

The tags comprise two main components; an antenna to communicate via radio signals with the reader, and an integrated circuit to store the unique ID code, customer data and to perform various radio frequency functions.

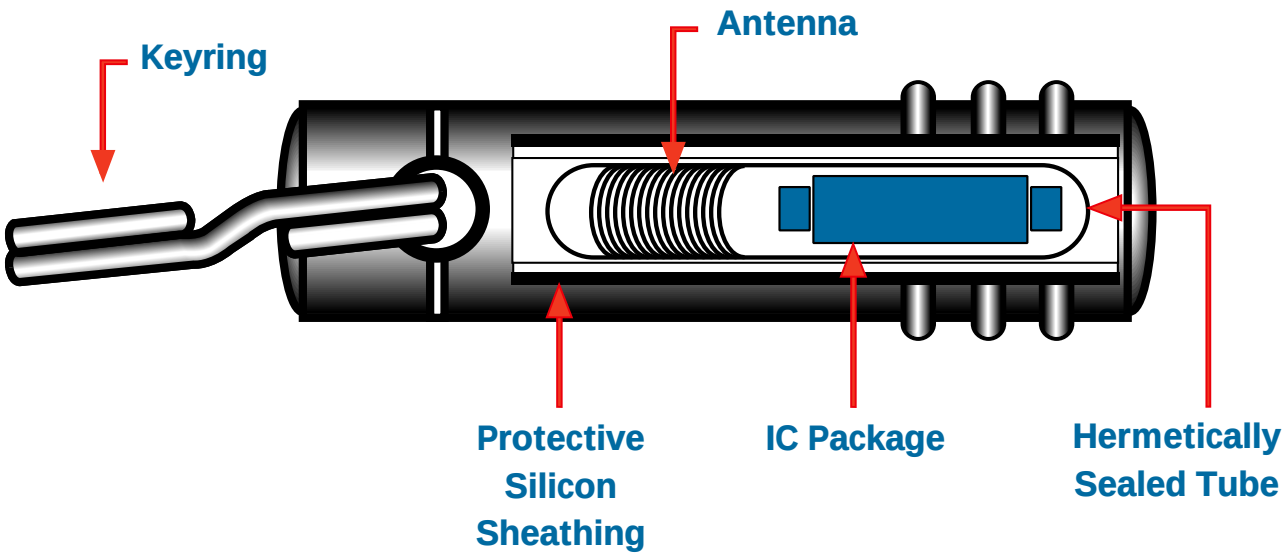
The keyring tag is battery-free, and draws its power from RF energy transmitted by the reader, and then stores it in an internal capacitor. The vehicle tag has a battery to provide more powerful signal strength and an extended read range. To extend the battery life, the vehicle tag has two modes: a sleep mode and an activation mode. Normally the vehicle tag is in sleep mode, drawing very little energy from the battery. The reader wakes the tag up when it enters the read zone, and initiates an activation mode; allowing it to communicate with the reader. Battery life for the vehicle tag is normally at least five years.

Tags never communicate credit card numbers–only a unique ID number.

The vehicle tag can operate in several different frequency bands, so that it is acceptable to all areas of the world.

The keyring tag attachs to a set of car keys for instant availability.

Keyring Tag



The keyring tag is packaged to withstand rough handling, and is test-proven to be durable under normal use.

The keyring tag features the following:

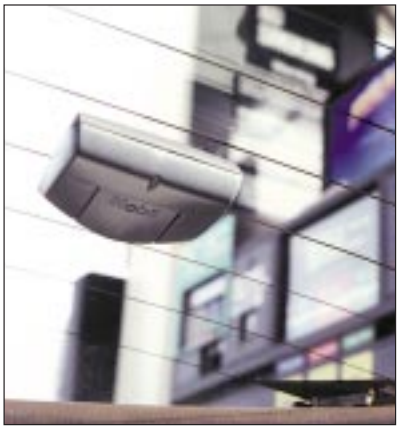
- Battery-free
- 134.2 kHz downlink, 134.2 kHz uplink
- 32-bit unique identification number
- 8-bit selective address
- 8-bit customer data
- 40-bit secret key
- Returns 24-bit signature on 40-bit challenge

Some retailers, especially those that do not serve drive-through customers, prefer to work with only the keyring tag. The reader system for this purpose is a subset of the S5000 Reader System, and can be upgraded to a reader system that includes the vehicle tag at any time.

Note: See the Product Catalog for a list of parts required to complete the S5000 Handheld Only System and to upgrade to a full system.

Vehicle Tag

TIRIS developed its unique patented low/ultra high frequency (LUHF) system specifically for the automatic refueling application where there is no margin for error in accuracy, and the correct customer must be billed every time. The vehicle tag is a compact high-performance identification device. It is activated with a 134.2 kHz downlink signal , which is also used to transmit data from the reader to the tag. The tag communicates back to the reader with a UHF (850-950 MHz) uplink signal, for fast and reliable data transmission. This frequency range means that the vehicle tag can be configured to operate worldwide, i.e. an uplink frequency can be selected to meet the requirements of the U.S., Europe, and the Far East. It uses 16 programmable channels to get around external frequencies that may block the communication link. The high frequency uplink signal requires no line-of-sight to communicate with the reader, and ensures reliable transmissions, particularly in environments where electronic interference might occur. The tag contains an integrated circuit, antenna and battery, and is mounted inside the rear window of a vehicle.



Vehicle tag.

Features	Benefits
Well-defined read zone	No cross-reads between fueling locations; accurate billing
Up to 8-foot read range	Reliable reading given vehicle variations
Tag orientation not critical	Mounting errors minimized
Wake-up signal	Saves battery life
Reads without line-of-sight	Reads through tinted windows, snow and objects
Multi-channel UHF uplink signal	Eliminates possible noise interference
Fast data rate	Good response time

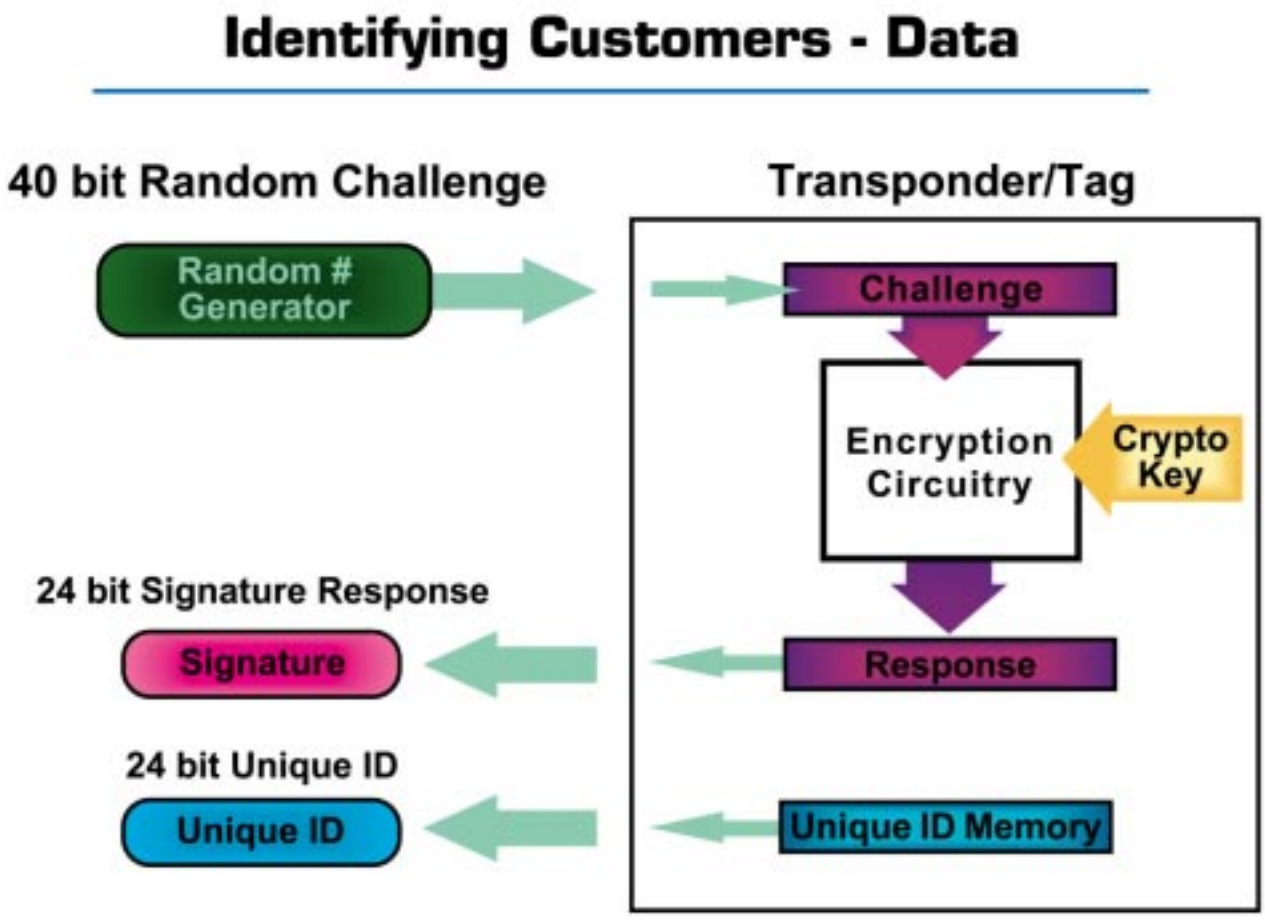
The vehicle tag specifications include the following:

- Active tag (with battery)
- 134.2 kHz downlink, 850-950 MHz uplink
- 16 programmable frequency channels
- 32-bit unique identification number
- 32 selective address flags
- Two 40-bit secret keys
- 16-bit customer data
- 8-bit country code
- Returns 24-bit signature on 40 bit challenge

Authentication and Network Processing

The TIRIS RFID system uses a high-quality challenge/response authentication feature to ensure that the tag is genuine. Based on a digital signature algorithm, it is nearly impossible to duplicate or counterfeit.

Each tag contains a unique ID code, at least one 40-bit secret key and a fixed digital signature processing algorithm. Before the tag is sent to a customer, the issuer programs a secret key into the tag and stores a copy of that secret key in a central database. Together with that secret key, the issuer also stores the number of the credit card, which the customer has indicated be linked to the tag. The unique ID code acts as the index number to find the secret key and the credit card number in the database.

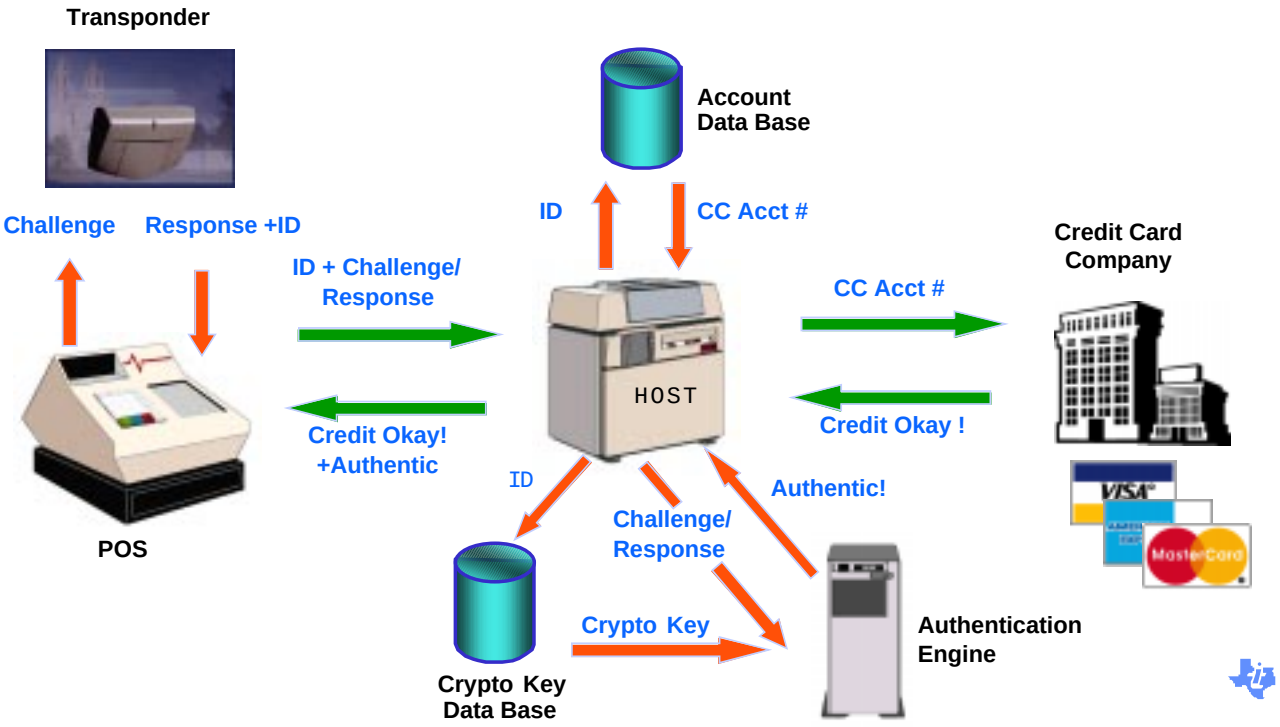


The transaction starts when a tag enters the read zone of an antenna and the reader receives the unique ID code. After receiving that number, the reader generates a random 40-bit number (called the challenge) and sends it to the transponder. The tag receives the challenge and uses that, together with its 40-bit secret key, as input to the digital signature processing algorithm. The execution of the algorithm results in a 24 bit response, that is returned by the tag as the digital signature.

The reader sends the unique ID code, challenge and response to the host computer. The host performs a lookup in the database to find the secret key and the credit card number that correspond to the tag. The challenge and the secret key are sent to the "authentication engine", a software routine that executes the same algorithm as the tag and also computes a 24-bit result. After this execution, the computer compares the digital signature of the tag with the result of the authentication engine. The tag is authenticated when both numbers are the same.

Once the tag is authenticated, the central computer sends the credit card number to the credit card host for authorization. A positive reply from the credit card host results in a green light for the transaction that is sent as an authorization approval to the reader. The complete authentication cycle takes no more than a few seconds.

Transaction Process



The Series 5000 Reader System

The Series 5000 Reader System controls the antennas to communicate with the TIRIS tags and passes the information of the tags on to a POS system or other type of host. It supports two keyring tag antennas and two vehicle tag antennas.

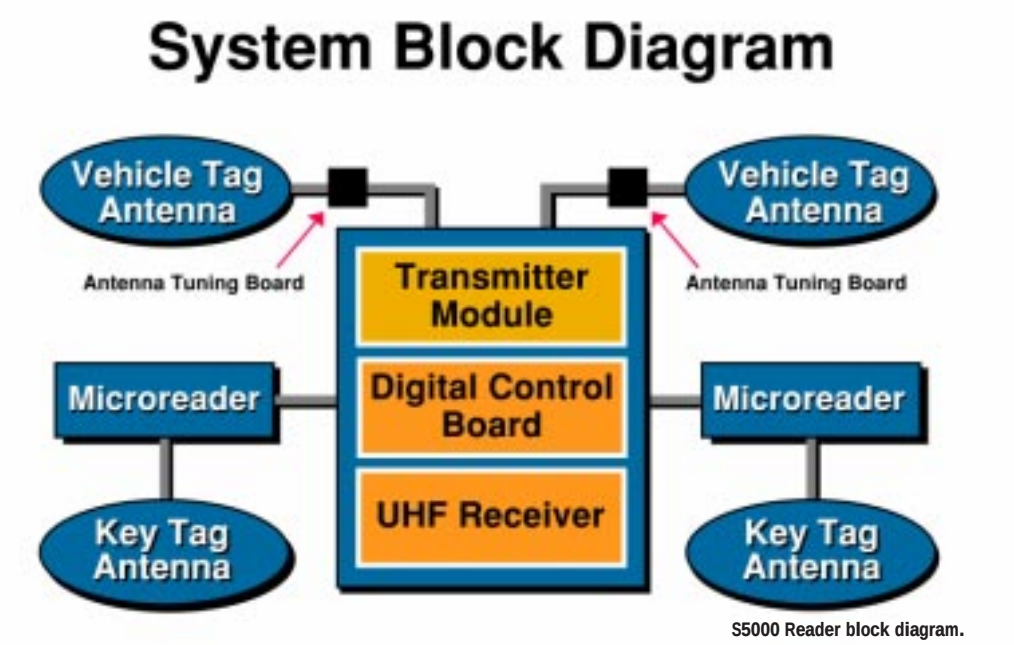
A complete reader system comprises:

- One Digital Control Board, the heart of the system. This board controls all other components and communicates with the host through an RS485 interface.
- One Transmitter Module that generates the signal for two downlink antennas, to activate the vehicle tags and send data to them.
- Two Antenna Tuning Boards and downlink antennas. The tuning boards are necessary to optimize the read performance by modifying the antenna inductance to compensate for production tolerances. The downlink antennas usually have to be custom made for the application and are therefore not provided by Texas Instruments.
- Two UHF Receive Antennas to receive the UHF signal coming from the vehicle tag.
- One UHF Receiver Module to control the UHF Receive Antennas. This module has to be mounted on to the DCB. The coax cable between the antennas and the UHF receiver is critical to the system performance and therefore supplied as part of the system.
- Two bezel boards with a Microreader, a keyring tag antenna and an indication light to let the customer know that he is recognized by the system. The bezel boards, the antenna, and the light usually have to be customized for the application and need to be designed by the system integrator. Texas Instruments only provides the microreader.

It is up to the system integrator to integrate all components into the dispenser, or into any other equipment where this system is targeted.

Integrators must provide the power supply, mounting brackets and cabling to make the reader functional.

The following illustrates the basic parts of a TIRIS S5000 Reader System for one double-sided retail fuel dispenser.



S5000 Reader block diagram.

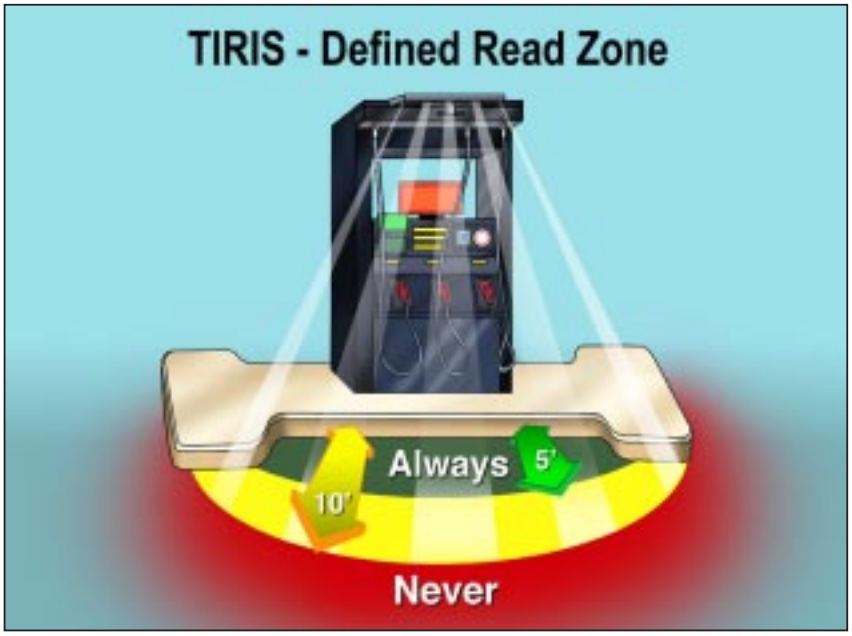
Well Defined Read Zone

The read zone–or read range–is the distance that tag and reader can be from one another for accurate and reliable communication. This well-defined read zone is what separates TIRIS from all other systems. Readers do not activate tags outside the read zone.

The read zone for a keyring tag in a dispenser system is intentionally reduced to 3 to 6 inches (up to 15 cm). This is done to avoid having a customer accidentally activate the dispenser when casually passing by, for example, walking to the convenience store. The customer has to deliberately present the keyring in front of the antenna to initiate a purchase transaction.

The read zone for the vehicle tag is defined as a specific area in front of the dispenser. This area is very critical. The TIRIS system is designed so that the vehicle tags are read when they are within a 5 feet (1.524 m) circle in front of the dispenser. This is the typical distance that results from normal driving behavior of the customer. The tags may be read in an area between 5 to 10 feet (1.524 m to 3.048 m) of the dispenser, but they are never read outside that area. The design approach chosen provides for a very definite drop off of the read zone at the boundaries of this space, thus ensuring that tags are not read outside the zone. This patented design eliminates the chance for cross reads between both sides of the dispensers.

The read zone is the distance that tag and reader can be from one another for accurate and reliable communication.



The well-defined read zone.

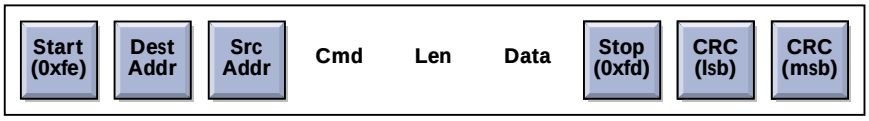
RS485-Based Data Communications

The S5000 Reader System has a protocol interface for the communication between the DCB and the host system. The interface is embedded in the firmware on the DCB. This firmware is responsible for the accurate and consistent identification of the RF signals. The protocol is based on the exchange of messages between the host system and the DCB. The DCB always acts as a slave and will only transmit a message over the RS485 line when instructed by the host.

The command field contains the command to be executed by the DCB and the data fields may contain the related data. The host can instruct the reader to read the transponder challenge and response data, turn on and off the recognition lights, turn on and off polling for tags.

The response code field contains the result of the executed command. It tells the host that the data is available, or that it is busy and not able to execute the command, or that there is an error in the transmission or execution of the command.

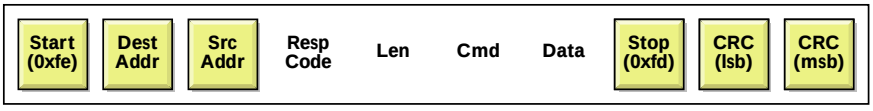
Data sent from the host to the DCB has the following message format:



The following table contains a list of the existing command codes:

RS485 Command Set for the POS System		
RS485 Command	**Decimal**	**Command**
0x40	64	Get Version
0x62	98	Get Antenna Scan Buffer – Format 1
0x63	99	Get Antenna Scan Buffer - Format 2
0x64	100	Get Variable Length Antenna Scan Buffer – Format 2
0x65	101	Get Read History
0x66	102	Get Variable Length Antenna Scan Buffer – Format 1
0x67	103	Echoes Test Data
0x68	104	Enables/Disable Dispenser Lamps
0x69	105	Enables/Disable Dispenser Lamp Control
0x6A	106	Gets Transponder Challenge Code
0x6B	107	Return Transponder Challenge Data
0x6C	108	Resume Polling
0x6D	109	Retry Variable Length Antenna Scan Buffer
0x6E	110	Set Parameters
0x6F	111	Stop Polling
0x71	113	Set Reader Options
0xFF	255	Time Sync

The response format is almost identical:



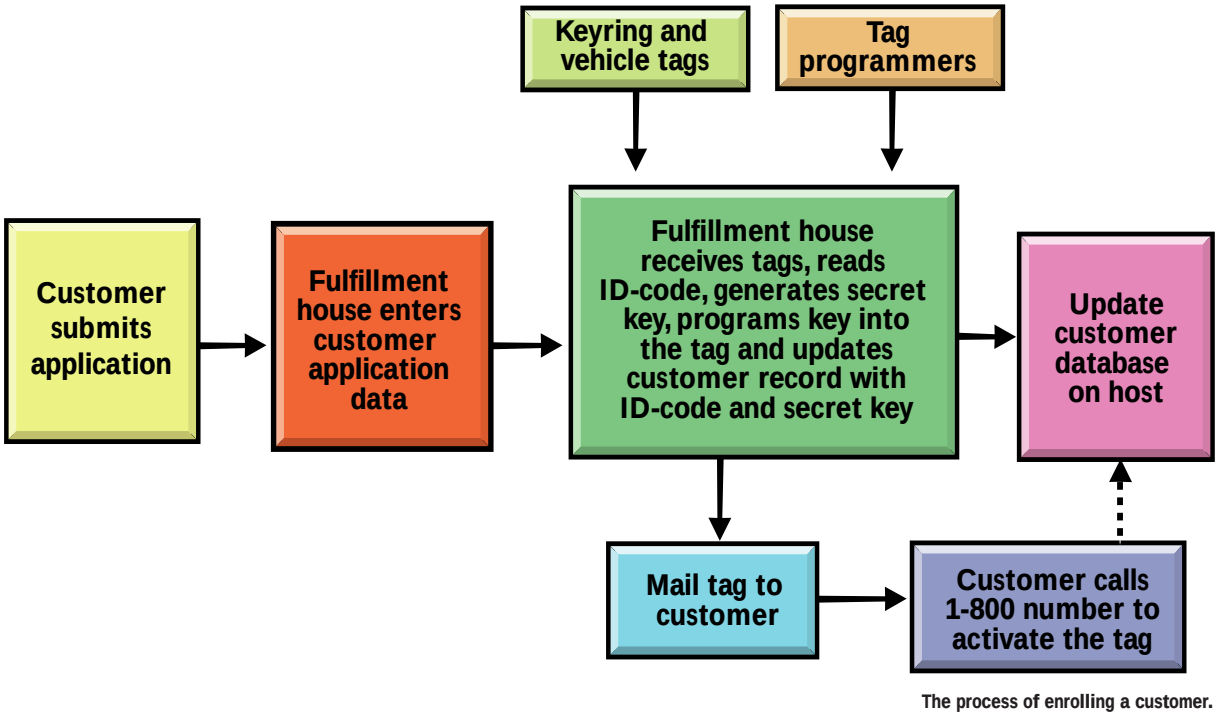
Fulfillment Process

Introduction

Tags leave the production line with just the unique ID codes programmed into them. All other pages in the tags are blank. Specific information, like customer data and the secret key, need to be programmed into a tag before it can be distributed. The process to collect the data, prepare the tags, put them in a box with matching instructions on how to install and use, and shipment to the customer is called the "fulfillment process." This is usually done at a fulfillment house.

The fulfillment house has to set up a database to store customer data. Besides trivial information like name, telephone number, address, city, social security number, maiden name etc., the database also has to store the secret key that is programmed into the tag and the type, number and expiration date of the credit card that the customer wants to use. Normally the customer provides the information by filling out a form, via the telephone or the internet. The fulfillment house stores the information in the database. For every customer, the fulfillment house first reads the unique ID code of the tag, generates a secret key for the tag, and then records this information in the customer's record.

The secret key is essential for the security of the system. If somebody were able to get a copy of the database, he/she could break the security of the system. Therefore, it is highly recommended to use an encryption algorithm to scramble the database.



The process of enrolling a customer.

The keyring tags are programmed wirelessly. Just put the tag on top of the antenna and send the right commands to the programmer.

The fulfillment process can be handled by an external company. In that case, the customer data has to be transferred to the central computer of the customer. It is also recommended to secure the data transfer with an encryption system.

Programming tags

The tags are programmed with a programming station. There are programmering stations for the keyring tag as well as for the vehicle tag. Both types can be controlled via a message protocol over an RS232 interface. The fulfillment house has to develop software to control the programming stations and link them to the database.

A typical programming sequence follows these steps:

- Read the unique ID code of the tag
- Make sure that the other pages are blank (not provided with customer data, not locked, ready to program)
- Program the customer data
- Program the secret key(s)
- Lock the data
- Store the unique ID code and secret key along with the other customer data in the database

Programming keyring tags

The keyring tag programmer contains a TIRIS Series 2000 Reader that is configured to program DST tags. There are two protocols to control the S2000; the ASCII protocol or the TIRIS Bus Protocol. Please see the S2000/S2510 Reader Manual and the DST updates for more information.

The keyring tags can be programmed wirelessly. Just put the tag on top of the antenna and send the right commands to the programmer. All commands generate return codes, which must be monitored to determine success or failure of the operation to assure that the tags were programmed correctly.

Programming keyring tags.

A tag is programmed by putting it into the fixture and sending the right command to the programmer.

Programming vehicle tags

The format of the interface protocol is identical to the TIRIS Bus Protocol, as described in the S2000/S2510 Reader Manual. The programming station uses the LRC Block Check Algorithm to check the validity of the messages. All available commands are described in the Vehicle Tag Programmer Protocol Definition.

The station has a fixture to hold the tag and connect the programming pins with the programming pads (located on the printed circuit board of the tag, under the battery). A tag is programmed by putting it into the fixture and sending the right command to the programmer. All commands generate return codes, which must be monitored to determine success or failure of the operation.

The tag can be removed from the fixture as soon as the application software indicates that the tag is ready. Then the customer installs the battery and the battery cover and performs a function test to make sure that the tag is working correctly.

Programming vehicle tag.

TIRIS Technology Terms

AM
Amplitude Modulation. The amplitude or strength of the carrier is varied in accordance with the amplitude and frequency of the information to be put on it.

ASK
Amplitude Shift Keying.

Downlink
RF data transmission from dispenser to tag (134.2 kHz carrier).

DST
Digital Signature Transponder. A tag that provides a one-way authentication challenge.

ETSI
European Telecommunications Standards Institute.

FM
Frequency Modulation.

FSK
Frequency Shift Keying. Form of frequency modulation in which the modulated signal of the output frequency shifts providing certain values to the data itself.

LF
Low Frequency. TIRIS equipment uses a 134.2 kHz low frequency signal for the downlink signal, which provides a definable, localized signal transmission. Because of the localization, cross-talks are prevented.

LUHF
Low / Ultra High Frequency.

OCC
Operations Credit Center.

POS
Point Of Sale, a system interface.

RF
Radio Frequency.

RFID
Radio Frequency Identification.

System integrators
TIRIS clients and partners.

System interface
The TIRIS LUHF system connects with the host system at the system interface.

Tag
A radio frequency tag provided to each user. For the S5000 Reader System, this can be either a handheld tag that clips to a keyring, or a vehicle tag that attaches to the inside of the vehicle's rear window. See also Transponder.

Transponder
A radio device comprising a transmitter and a responder. It is used in conjunction with an interrogator, usually called a reader. Same as tag.

UHF
Ultra High Frequency. The frequency band between 300 MHz and 1000 MHz. This uplink RFID signal of the S5000 Reader System can be programmed between 850 and 950 MHz.

Uplink
RF data transmission from tag to dispenser (850-950 MHz Carrier).