

**ALIEN TECHNOLOGY®**

# **HARDWARE SETUP GUIDE**

**ALR-9890 - RR**

**Aug 2006**



**ALIEN®**

**ALR-9890 - RR**

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## FCC Compliance (RF Devices)

This equipment has been tested and found to comply with Part 90 of the FCC Rules and Regulations. A separate site license is required for each installation. It is the responsibility of the system integrator/installer or user to obtain the site license.

## FCC Compliance (Digital Devices)

This equipment had been tested and found to comply with the limits of 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 operated 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 with radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which the user will be required to correct the interference at his own expense.

Any change or modification to this product voids the user authority to operate per FCC Part 15 Subpart A. Section 15.21 regulations.

## Caution

The ALR 9890 – RR is a source of RF energy. When connected to a system including an antenna the radiated RF emissions must be evaluated in accordance with FCC OET Bulletin 56 "Hazards of radio frequency and electromagnetic fields" and Bulletin 65 "Human exposure to radio frequency electromagnetic fields" and appropriate precautions implemented. **All individuals working on or near the antenna should not be closer than 1.71 feet (52 CM) to the antenna when the RFID reader is operating into a 10 dBi antenna.** This is the minimum distance for human exposure recommended by FCC OET Bulletin 56.

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# CHAPTER 1

## Introduction

This *Hardware Setup Guide* provides instructions for installing and operating the ALR-9890 RFID Readers.

This document is designed for use by RFID system integrators and software developers - those who wish to develop software products and extended systems that take full advantage of the RFID Reader's capabilities.

### Audience

For the purposes of this document, we assume the readers of the *Hardware Setup Guide*:

- Are competent PC users
- Have minimal previous knowledge of Radio-Frequency Identification (RFID) technology and be competent in the installation of RF antenna and cabling.
- Are experienced in software development and/or hardware systems integration

### RFID Reader Overview

The Alien ALR-9890 RFID reader is designed to read any tag conforming to the Association of American Railroads Standard for Automatic Equipment Identification - AAR S-918 protocol (commonly found on rail cars) or EPC Class 1 Generation 2 protocol. Additionally the reader detects input event timing and issue event reports (tag reads and IO events) to a host computer system. The host computer can be locally connected to the reader via RS-232, or at a remote network location.

The RFID Reader is delivered with the following components and accessories:

- One (1) RFID Reader
- One (1) power supply and cord
- Two circulator assemblies

The reader is intended to be operated in a system comprising the reader, its power supply, two circulator assemblies and one or two external antennas. Each individual system installation requires a site license issued by the FCC. It is the responsibility of the system integrator/installer or user to obtain the site license.

## UHF RFID Tags

The Alien ALR-9890 RFID reader is designed to read any tag conforming to AAR S-918 (commonly found on rail cars) or EPC Class 1 Generation 2 protocols.

Rail tags are both “passive” and “semi-passive”. EPC tags are passive only. Passive tags derive their operating power from the incident RF field of the reader through rectification of the incident wave. Semi passive tags derive their operating power from a battery or other power source.

Both passive and semi-passive tags communicate with the reader through backscatter modulation in which the tags do not actually transmit RF energy. Instead, they change their reflective characteristics in a systematic way and reflect RF energy back to the reader. An analogy to this is the way you can use a mirror to transmit information by reflecting light from the Sun.

## Requirements

To interface with the ALR – 9890 Reader you will need the following:

- A PC running Windows 98 or higher, with CD-ROM drive, an available RS-232 serial port, and Ethernet connectivity
- Standard 120/220 VAC 50/60 Hz
- Power supply and cord (included with reader)
- Host software (Alien Gateway demo software or your own custom software)

## Specifications

Specifications for key components of the RFID Reader system are provided in the tables below:

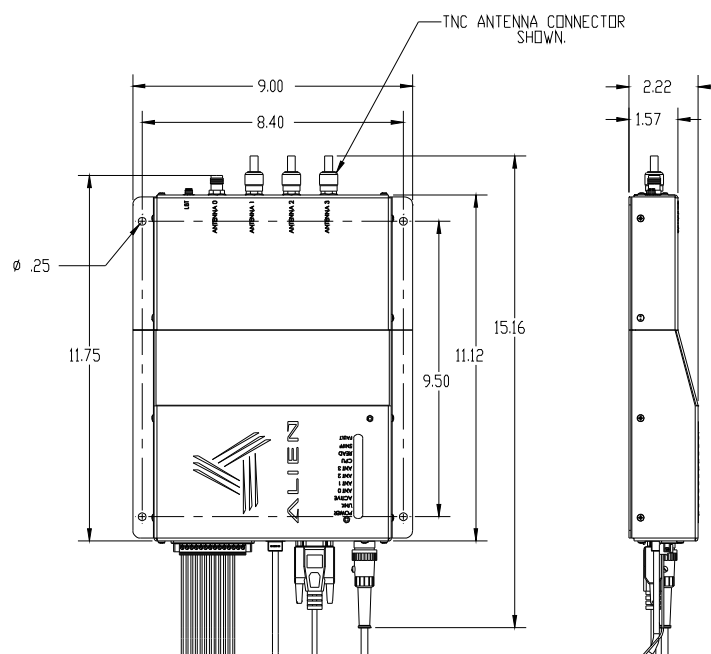
### RFID Reader

<b>Name</b>	Alien Railroad Reader
<b>Model Number</b>	ALR 9890 - RR
<b>Operating Frequency</b>	910.75 MHz – 920.75 MHz
<b>Channels</b>	21 Fixed Frequency Channels (User selected based on site license)
<b>Channel Spacing</b>	500 KHz
<b>RF Transmitter</b>	33 dBm
<b>Modulation Method</b>	Vector Modulation
<b>RF Receiver</b>	2 Channels
<b>Power Consumption</b>	45 Watts (120 VAC at 600 mA)
<b>Communications Interface</b>	RS-232 (DB-9 F), TCPI/IP (RJ-45)
<b>Reader RF Interface</b>	4 reverse polarity TNC connector antenna ports (note 1)
<b>Antenna Interface (See Antenna Note below)</b>	A circulator assembly interfaces to two reader antenna ports (RP-TNC plug) and one external antenna port (Type N jack)
<b>Inputs/Outputs</b>	4 optically isolated inputs, serial com port, LAN, power
<b>Dimensions</b>	(L) 9.0" (22.9 cm) x (W) 11" (28 cm) x (D) 2.22" (5.6 cm)
<b>Weight</b>	Approximately 1.8 kg (4 lb)
<b>Operating Temperature</b>	0°C to +50°C (+32 °F to +122°F)
<b>LED Indicators</b>	Power, Link, Active, Ant0-3, CPU, Read, Sniff, Fault (red)
<b>Compliance Certification</b>	FCC Part 90 (Site license required) note 1 UL 60950-1

**Note 1: This product has been designed to be compliant with FCC part 90 (LMS) requirements when using antennas with not more than 10 dBi of gain.**

**Professional installers: Ensure your location does not use more than 10 dBi gain antennas.**

### Mechanical: Reader Physical Size



NOTES:

- NOTES:
1. ALL MEASUREMENTS ARE IN INCHES.
  2. DIMENSIONS BASED ON CURRENT READER X PROTOTYPE.
  3. DIMENSIONS SUBJECT TO CHANGE AS THE DESIGN ADVANCES.

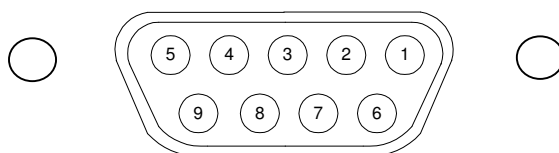
Figure 1 - Outline Drawing of the ALR-9890 - RR



## RS-232 Port Pinouts

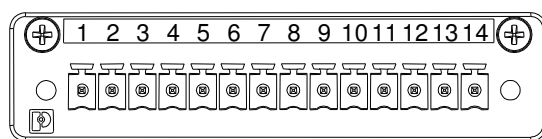
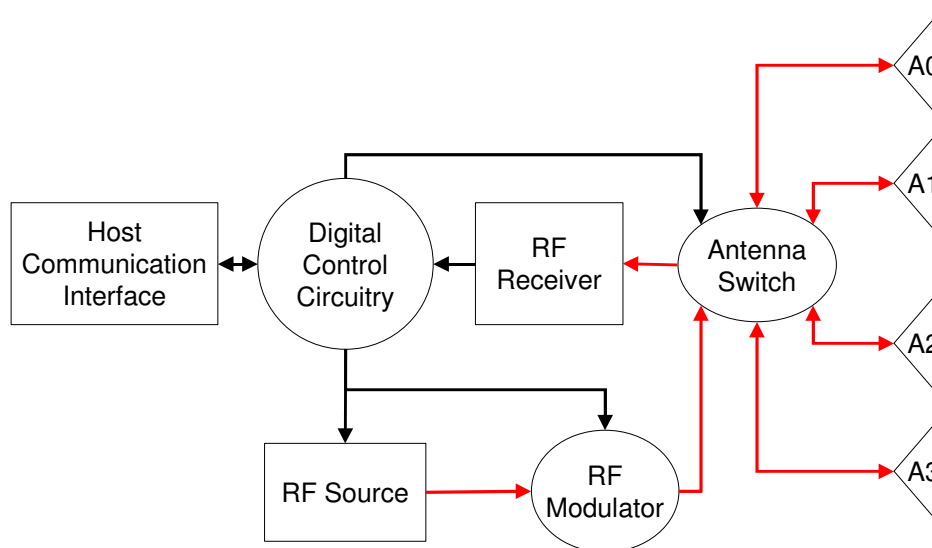
RS-232 Connector (Female DB-9F)	
Pin 1	DCD Connected to Pin 6
Pin 2	TR1 Transmit Data (Output)
Pin 3	RC1 Receive Data (Input)
Pin 4	DTR Connected to Pin 6
Pin 5	Ground
Pin 6	DSR Connected to Pin 4
Pin 7	RTS Connected to Pin 8
Pin 8	CTS Connected to Pin 7
Pin 9	Not Connected

## RS-232 CONNECTOR (FEMALE) – LOOKING AT READER



## IO Port Terminal Interface

I/O Port Screw Terminal Connector (Female DB-9M)	
Pin 1	V+
Pin 2	Not connected
Pin 3	Not connected
Pin 4	Not connected
Pin 5	Not connected
Pin 6	Not connected
Pin 7	Not connected
Pin 8	Not connected
Pin 9	Not connected
Pin 10	Input 0
Pin 11	Input 1
Pin 12	Input 2
Pin 13	Input 3
Pin 14	V-

**I/O PORT SCREW TERMINAL (FEMALE) – LOOKING AT READER****System Architecture**

*Figure 2 - System Architecture for the ALR-9890 – RR Reader*

# CHAPTER 2

## Reader Hardware Installation and Operation

This chapter describes the RFID Reader and provides installation and operation information.

### Receiving the RFID Reader

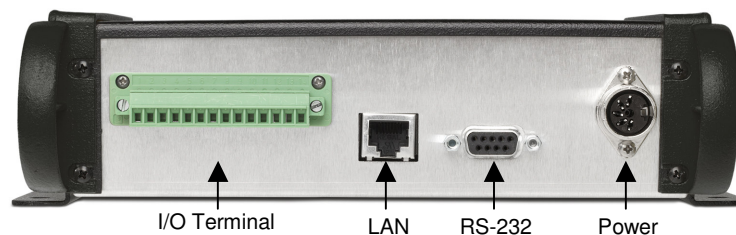
Your RFID Reader is shipped as an individual reader kit with the items listed below. Please verify the contents of your received shipment before assembling.

- RFID Reader
- Power supply and cable
- Circulator Assembly

### Reader I/O Panel

The I/O panel (shown below) houses the following:

- 14-pin female I/O terminal block
- LAN TCP/IP port
- 9-pin D female RS-232 serial port
- Power connector



*Figure 3 - ALR-9890 -RR Reader Connections*

## Diagnostic LEDs

The ALR-9890 - RR includes diagnostic LEDs on the face of the reader to provide easy and convenient external indication for various operating conditions:

- **POWER (green)** - indicates power is applied to the reader
- **LINK (green)** – indicates that the reader is connected to the network
- **ACTIVE (green)** – indicates reader is transmitting on the network
- **ANT 0 – ANT 3 (green)** – indicates that the reader is transmitting power on the specified antenna port
- **CPU (green)** – indicates that the CPU has booted successfully and is running normally.
- **READ (green)** – indicates that the reader is receiving data from a tag
- **SNIFF (green)** – indicates a tag signal has been detected, though it may not be strong enough yet to complete a transaction.
- **FAULT (red)** – indicates a fault condition with the reader.

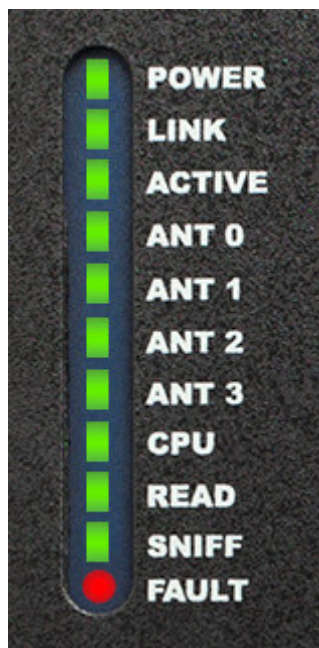


Figure 4 – ALR-9890 – RR Reader Diagnostic LEDs

## Antenna Panel

The antenna panel (opposite the reader's I/O panel) contains four coax antenna connector ports as shown below. These are reverse-polarity TNC connectors. Also included on this panel is the Listen Before Talk (LBT) connector (unused in this model).



*Figure 5 - Antenna Connections*

## System Assembly and Bench Test

Assembling the RFID Reader system is easy. We recommend you set up the system and verify its operation in a bench test configuration before installing it in a production setting.

### Bench Test Configuration

**1. Place the Reader on a tabletop.** Ensure the following conditions:

- A standard 120 or 220 VAC outlet is nearby.



*Figure 6 - RS-232, LAN, and Power Connections*

- Sufficient space is available on the tabletop for the reader, circulator assembly and antenna.

**2. Connect the RS-232 cable to the reader.**

- Align the male cable connector so that its shape and pins match the shape and holes of the female DB-9 RS-232 port.



*Figure 7 - RS-232 Connector*

- Push the aligned connector into the port.
- Finger-tighten the screws to secure the cable/connector to the reader.

**3. Connect the RS-232 cable to the serial port on the PC.**

- Settings for RS-232 are 115200 Bits per second, 8 data bits, no parity, 1 stop bit, and no flow control.
- Start up terminal software on the PC, such as HyperTerminal with these settings, and be prepared to observe the reader's messages as it boots up.
- The RS-232 port serves only as console output for the reader at this time. It displays useful information while the reader boots, including network settings.

#### 4. Connect the Ethernet cable to the reader and PC or LAN.

- You must use TCP/IP to communicate with the reader, so connect a standard ethernet cable from the reader to a nearby LAN drop or network switch.
- You may alternatively use a cross-over ethernet cable and connect the reader directly to the PC.
- The reader comes pre-configured to look for a DHCP server to set its network parameters. In the absence of a DHCP server, the reader will use the following settings:
  - IP Address: 192.168.1.100
  - Subnet Mask: 255.255.255.0
  - Gateway: 192.168.1.1

#### 5. Connect the power supply to the reader.

- Using the thin cable attached to power supply, push the connector into the port until it is securely seated. Do not plug the power supply into the wall outlet yet.
- Finger-tighten the securing ring onto the connector.
- The ALR-9890 – RR power supply has a safety feature that turns the power supply off in the event that it detects an abnormal AC line condition. When this happens, the green LED on the power supply brick will not be lit. To reset the power supply, unplug the AC power cord from the wall or power strip, and plug the power cord back in.

#### 6. Connect the antenna(s) to the reader.

The reader may be used in a multi-static or mono-static mode. In the multi-static mode each antenna port is connected to a separate antenna. In the mono-static mode a circulator assembly is used to split the transmit and receive paths.

##### Multi-static Case

- Connect the antennas to the individual ports. Refer to Applications Note AN17001.

##### Mono-static Case (Install Circulator Assemblies)

**Caution:** It is important to connect the correct circulator port to its associated antenna port. Damage to the reader may result if they are connected incorrectly.

- Antenna port 0 of the reader is on the top right-side, if viewing the reader from the front with the flange side down. It has been labeled for convenient identification. The ALR-9890 – RR has four (4) antenna ports.
- The circulator assembly cables are labeled Ant 0, 1, 2 and 3 and Ant A or B.
- Align the Ant 0 coax cable's center pin and push into the corresponding port.

- Screw the fitting from the cable end onto the reader connector *clockwise* until finger-tight to secure the cable to the reader.
- Connect the remaining antenna cables (Ant 1, 2 and 3) to their respective ports and tighten fittings clockwise until finger-tight.
- Align the Ant A coax cable's center pin and push into the corresponding port.
- Screw the fitting from the cable end onto the reader connector *clockwise* until finger-tight to secure the cable to the reader.
- Repeat this process for ANT – B if required.
- If using the Alien Gateway software, please note that ANT 0 is selected by default when first initialized.

**7. Plug power cord into power supply.**

- Use the female end of a standard 3-pronged power cord (a power cord is included with each reader)

**8. Plug the power supply cable into the wall outlet and verify power.**

- The green POWER LED will illuminate when power is on.

**9. Observe the reader's bootup trace, and determine the network settings.**

Toward the end of the trace, the reader displays a block of text similar to the following:

```
=====
-----
Network Settings:
  MAC Address : 00:80:66:10:2D:12
  DHCP       : 1
  IP Address  : 10.9.8.10
  Netmask    : 255.255.255.0
  Gateway    : 10.9.8.2
  DNS        : 10.9.8.1
  TimeServer  : time-a.timefreq.bldrdoc.gov
  TimeZone   : -7
-----
=====
```

**10. Ensure the PC has compatible network settings.**

- In order for you to be able to connect to the reader over TCP/IP, the host PC must be on the same subnet as the reader. If you are unfamiliar with how to do this, consult your local IT service for assistance.
- Once the initial connection is made, you may configure your reader's network settings as you choose. Refer to the *Reader Interface Guide* for instructions on how to do this.



## Input Configuration

The Reader includes four optically isolated inputs. These may be used to notify the reader of external events. The reader can react to and/or report the occurrence and timing of input events. The reader inputs are designed to accept a 5 volt signal. The absolute maximum is 8 volts. The user must supply an external fixed voltage power supply to drive the optically isolated circuits.

The input circuit consists of a 1 kohm resistor in series with a photo diode. The cathode of the diode is connected to the V- pin of the IO connector. The input is energized by supplying +5 volts DC between the input pin and the V- pin of the IO connector. The input is de-energized by opening the connection to the input pin of the connector.

The external power supply can be 12 or 24 volts. A quarter watt resistor is required in the input circuit so that the voltage to the input is approximately 5 volts when energized. The resistor value for 24 volts is ~3.6 kohm at the input circuit to account for all voltage drops and power dissipation for proper operation and reliable performance in the intended application.

***You are now ready to bench test or demonstrate the RFID Reader system.***

## Bench Test Procedure

*The ALR 9890 – RR is a source of RF energy. When connected to a system including an antenna the radiated RF emissions must be evaluated in accordance with FCC OET Bulletin 56 “Hazards of radio frequency and electromagnetic fields” and Bulletin 65 “Human exposure to radio frequency electromagnetic fields” and appropriate precautions implemented. Avoid close, prolonged exposure to the RF emissions through good laboratory practice including:*

- *Turn off transmission when not making measurements*
- *Aim antenna away from personnel when in use.*
- *Maximize distance between the antenna and people.*

### 1. Access an operational mode suitable for bench testing.

- The reader defaults to the AAR – S-918 protocol on boot up.
- Reading of Class 1 Generation 2 tags may be enabled under command in the Gateway application.
- Refer to the applicable software application user guide for specific instructions.

### 2. Position the reader so you can see the diagnostic LEDs.

- You may also want to position the PC so you can view the monitor simultaneously for later tests.

### 3. Move a tag slowly away from the antenna’s range.

- Begin with the tag well inside the expected read range (~2m or 6 ft) and move it toward the antenna while observing the LEDs.

### 4. Verify the SNIFF LED illuminates when the tag approaches the read window.

- SNIFF should be illuminated green.

### 5. Verify the READ LED illuminates when the tag is inside the read window.

- READ should be illuminated green.

### 6. Verify the host receives the tag data.

- Refer to indications specified in applicable user guide to verify the tag was read successfully.

### 7. If bench test conditions are verified, proceed to installation.

*NOTE: To perform a hard reboot of the system, simply cycle power on the reader.*

## Installation

This section provides guidance for configuring components in your RFID system. You should consider the overall design of your specific system before permanently mounting the equipment. The reader is designed and certified for indoor operation.

Installation involves all the same connection steps required for bench test. However, instead of placing equipment on a tabletop, the reader, antenna, and their accessories are mounted in your application environment. The installation must protect the reader from conditions outside of its designed environment.

## Requirements

Before installing your RFID Reader system, you will need the following:

- A PC running Windows 98 or higher, with Ethernet connectivity and, optionally, one available RS-232 serial port.
- Standard 120 or 220 VAC power for the reader
- Host software (Gateway, for example)
- (Optional) extra antennas (if desired for additional coverage or configurations)
- Additional RS-232 cables or antenna coax cables needed to accommodate routing requirements
- Standard grounded, three-pronged power cord of desired length
- Mounting hardware suitable for the surface to which equipment is to be attached (e.g., wood screws, moly-bolts, brackets, etc.)



Figure 8 - View of the Reader showing mounting holes

## Hardware Installation Procedure

**CAUTION:** The ALR 9890 – RR is a source of RF energy. When connected to a system including an antenna the radiated RF emissions must be evaluated in accordance with FCC OET Bulletin 56 “Hazards of radio frequency and electromagnetic fields” and Bulletin 65 “Human exposure to radio frequency electromagnetic fields” and appropriate precautions implemented.

1. Select mounting position for reader.

- Reader should be positioned close enough to the antenna to accommodate the cable length without putting strain on the connectors.
- Be sure power is available at the selected reader location.

## 2. Install reader.

- Secure the reader through the two mounting holes on either flange to its mounting location (wall, post, mounting bracket) using appropriate hardware.
- If desired, position the reader so that the LEDs are easily observed.
- It is recommended, if the reader is mounted vertically, the Antenna ports be oriented at the top.

## 4. Connect the antenna(s) to the reader.

The reader may be used in a multi-static or mono-static mode. In the multi-static mode each antenna port is connected to a separate antenna. In the mono-static mode a circulator assembly is used to split the transmit and receive paths.

### Multi-static Case

- Connect the antennas to the individual ports. Refer to Applications Note AN17001.

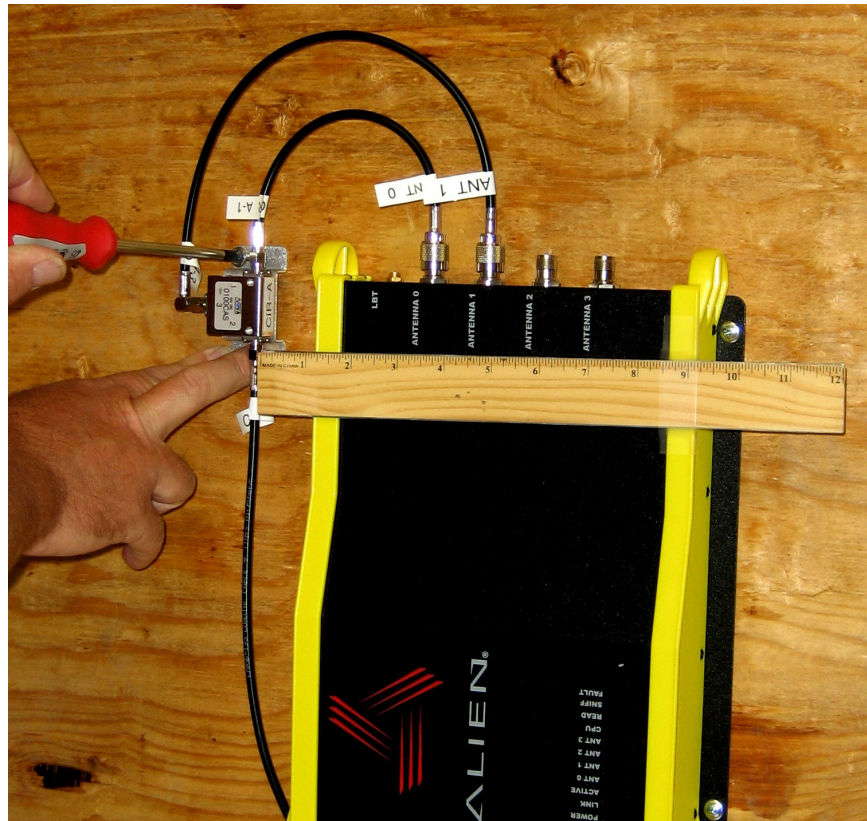
### Mono-static Case (Install Circulator Assemblies)

**Caution:** It is important to connect the correct circulator port to its associated antenna port. Damage to the reader may result if they are connected incorrectly.

The Circulator Assemblies have been pre-assembled and labeled to ease installation. Prior to installing the circulators make sure the antenna lines reach the bottom left corner of the mounted reader.

- Take Circulator Assembly A and attach the 2 TNC connectors labeled ANT 0 and ANT 1 to the reader jacks labeled ANT 0 and ANT 1 respectively. Hand tighten only!
- Take Circulator Assembly and rotate it counter-clockwise until the single cable is hanging straight down.
- Place Circulator A so that it is about 1" to the left of the reader and the top of the circulator is flush with the top of the mounted reader.
- Make sure the 2 attached cables are not strained or binding.

- Attach Circulator A to panel.



*Figure 9- Circulator Assembly*

- Take Circulator B and attach the 2 TNC connectors labeled ANT 2 and ANT 3 to the reader jacks labeled ANT 2 and ANT 3 respectively. Hand tighten only!
- Take the Circulator Assembly and rotate it counter-clockwise until the single cable is hanging straight down.
- Place Circulator B so that it is about 1.5" to the left of the Circulator A and the top of Circulator B is about 1.25" below the bottom of Circulator A.
- Make sure the 2 attached cables are not strained or binding.

- Attach Circulator B to panel as shown in picture.

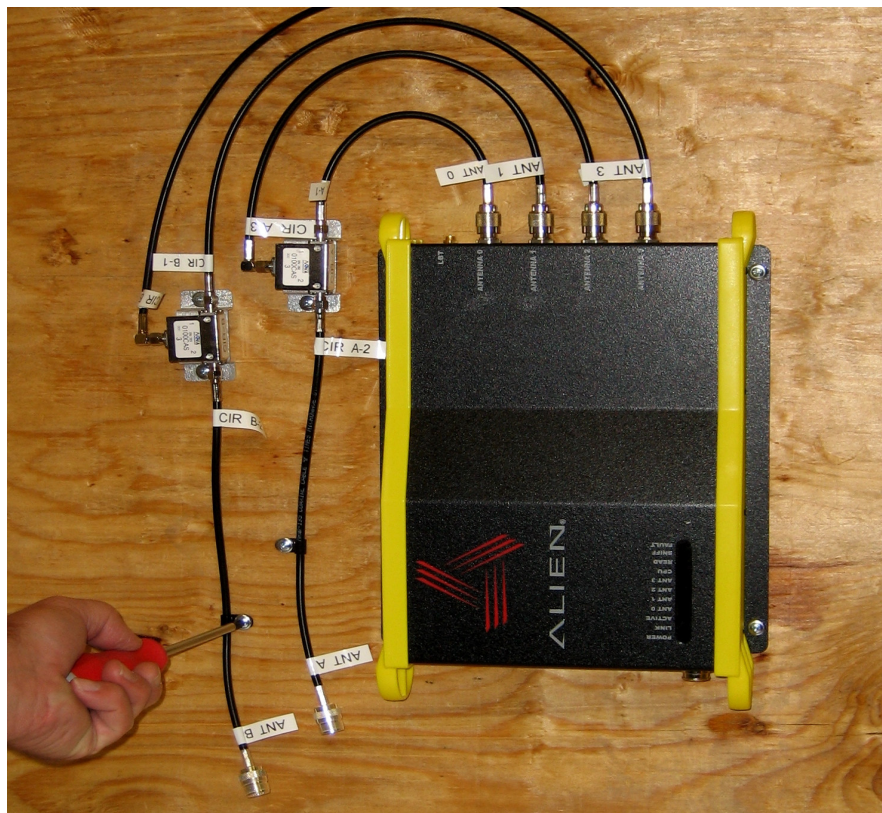


Figure 10- Circulator Assembly

- Place a P-Clip around each hanging cable.
- Measure down a little past the middle of each cable (approx. 7"-8") and attach the P-Clip to the panel.
- Make sure the cable is not binding or strained at the circulator connection.
- Tighten the screws so that the cable inside the P-Clip cannot slide through.
- Check to make sure all of the connectors are at least hand tight.
- If any of the connectors attached to the circulators have come loose hand tighten, and then using the 5/16" open end wrench tighten a **1/8 turn only**.
- **Caution: Do not over tighten connectors!**
- Route coax cables from the antennas to the reader according to your system design specifications and secure them properly.
- Attach the Type N-Female Antenna Lines A and B to the correct antenna lines.
- Align the connector for each cable with the reader antenna port, push into the port, and finger-tighten the screw fitting.

##### 5. Connect reader power.

- Install the reader power supply. Be sure it is securely mounted.

- Push the power supply connector into the reader port and tighten the retaining ring finger tight.
- Plug the female end of the power cord into the power supply.
- Plug the male end of the power cord into the 120 VAC outlet.

#### 6. Connect reader to the LAN or host PC.

- Align the RJ-45 connector with the corresponding TCP/IP port on the reader and push the connector in. Connect to the other end to a LAN drop or network switch. You may optionally connect the reader directly to a PC's network port, but you must use an Ethernet cross-over cable in this situation.
- If you wish to observe the reader's bootup trace, align and connect a DB-9 serial cable to the reader's RS-232 port, and to the serial port on the PC. Configure your terminal software as described previously in the Bench Test Configuration topic.

#### 7. Connect any IO circuitry.

- Connect the user IO circuitry to the IO mating connector.
- Align the connector with reader connector and insert.
- Tighten the screws to hold the connector to the reader..

#### 8. You are now ready to use the reader. If using the Alien Gateway software, please refer to the *Demonstration Software Guide* included on your CD.

#### 9. Set Channel Frequency

After the reader boots up, set the frequency specified on the site license using the following command on the Alien Gateway software command line interface.

**F = n**

where n is an integer between 0 and 20 and where 0 sets the frequency the lowest channel (910.75 MHz) and 20 sets the frequency to the highest channel (920.75 MHz). Upon initial power up and boot up, the default channel that will come up, if no channel is set, is channel 10. As a guide the following table relates channel number to the frequency of the reader.

**ALR9890-RR Channel Frequencies**

Chan.	Freq. (MHz)	Chan.	Freq. (MHz)	Chan.	Freq. (MHz)	Chan.	Freq. (MHz)
0	910.75	6	913.75	12	916.75	18	919.75
1	911.25	7	914.25	13	917.25	19	920.25
2	911.75	8	914.75	14	917.75	20	920.75
3	912.25	9	915.25	15	918.25		
4	912.75	10	915.75	16	918.75		
5	913.25	11	916.25	17	919.25		



The frequency set by the  $F = n$  command will be entered into the reader nonvolatile memory and will come up at that frequency any time the reader is restarted.

## System Operation: Software Control

The ALR-9890 – RR RFID Reader is controlled from software running on a host system that communicates with the reader using the ASCII-based Alien Reader Protocol. All applications use this protocol to communicate with the reader.

You may operate the reader from your own application code, using the example code provided on the Developer's Kit CD, or using the Alien RFID Gateway application which is a demonstration program also included on your CD.

For more details, refer to either the *Reader Interface Guide* or the *Demonstration Software Guide* described briefly below.

### Reader Interface Guide

The Alien Reader Protocol, mentioned previously, is described in detail in the *Reader Interface Guide*. Using this interface, the reader can be configured to read tags when queried or after one of a variety of event triggers (e.g., a rising edge on one of the I/O pins, or a timer).

Tag data acquired in response to these triggers can be transmitted to the host in a number of formats (e.g., text, XML or custom) and under a number of conditions (e.g., on a new tag being observed, or a tag disappearing from view).

If you are a software developer, the *Reader Interface Guide* provides the information you will need to connect to the reader from a host computer, communicate with it, and customize its performance.

### Demonstration Software Guide

The *Demo Software Guide* describes the installation and operation of the Alien RFID Gateway application.

The Alien RFID Gateway application is a useful demonstration program that allows users to explore the reader's functionality and build customizable demos with a user-friendly interface.

Using the Gateway, the various operating modes of the reader can be controlled and custom interactive demos can be constructed using sounds, images, and text.

### Alien RFID Academy

Need to absorb RFID systems fast? Enroll in the Alien RFID Academy. In three days we'll share our practical expertise in RFID Tags, Antennas, Readers, Frequencies, Systems, and Protocols.

The Alien RFID Academy is a hands-on immersion into the workings, uses, and challenges of RFID technology. Rather than a product pitch, we put products to the test in the classroom, provide students with hands-on exposure in our RFID Solutions Center, and short-cut the learning curve by sharing practical solutions



to real-world challenges. You'll learn best industry practice tag placement techniques for packaging and pallets alike.

Upon completion of the training, you will learn how to implement, avoid common costly mistakes, know how to make the correct decisions for your business, how to select the right RFID options for your requirements, and where to find RFID answers.

**Alien RFID Intermediate / Advanced Academy Topics:**

- RFID Physics, Protocols & Practical Applications
- Tag Placement & Packaging Considerations
- RFID Reader/System Configuration & Optimization
- Hands-on Implementation
- RFID System Architecture and Integration
- Conducting Site-surveys & Contending with Interference

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