AI1422 Half-Frame Reader
User Guide

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WARNING TO USERS IN THE UNITED STATES

FEDERAL COMMUNICATIONS COMMISSION (FCC)
LOCATION AND MONITORING SERVICE STATEMENT
47 CFR §90.351

NOTE: The user is required to obtain a Part 90 site license from the FCC to operate this radio frequency identification (RFID) device in the United States. See product label for FCC ID number. Access the FCC Web site at www.fcc.gov/Forms/Form601/601.html or at wireless.fcc.gov/index.htm?job=online_filing to obtain additional information concerning licensing requirements.

NOTE: Users in all countries should check with the appropriate radio regulatory authorities for licensing requirements.

FCC RADIO FREQUENCY INTERFERENCE STATEMENT
47 CFR §15.105(a)

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 operated in a commercial environment. This equipment generates, uses, and can radiate RF energy and may cause harmful interference to radio communications if not installed and used in accordance with the instruction manual. Operating this equipment in a residential area is likely to cause harmful interference, in which case, depending on the regulations in effect, the user may be required to correct the interference at their own expense.

NO UNAUTHORIZED MODIFICATIONS
47 CFR §15.21

CAUTION: This equipment may not be modified, altered, or changed in any way without permission from TransCore, LP. Unauthorized modification may void the equipment authorization from the FCC and will void the TransCore warranty.

USE OF SHIELDED CABLES IS REQUIRED
47 CFR §15.27(a)

NOTE: Shielded cables must be used with this equipment to comply with FCC regulations.

TransCore, LP
USA

Health Limits

Within the United States, environmental guidelines regulating safe exposure levels are issued by the Occupational Safety and Health Administration (OSHA).

Section 1910.97 of OSHA Safety and Health Standards 2206 legislates a maximum safe exposure limit of 10 milliwatts per square centimeter (mW/cm^2) averaged over 6 minutes at both 915 and 2450 MHz.

Although not binding, other organizations such as the American National Standards Institute (ANSI) have issued similar guidelines that are more restrictive than the OSHA limits (ANSI C95.1). ANSI guidelines recommend a maximum safe power density in mW/cm^2 of:

Frequency **(in MHz)**
1500

Thus, the maximum permissible exposure for general population/uncontrolled exposure at 915 MHz is 0.61 mW/cm^2. The power limit is a six-minute average.

The RF power density generated by the AI1422 Half-Frame Reader was calculated using a maximum antenna gain of 12 dBi, equivalent to the antenna gain used in a typical AI1422 Half-Frame Reader installation.

Note: *The calculated RF power density that is presented here assumes 0-dB cable loss, resulting in the highest radiated power.*

Warning

The antenna gain should not exceed 12 dBi. To avoid exceeding the RF safety limits established for this product, the antennas used for this transmitter must not be located within 8 inches (20 cm) of or operated in conjunction with any other antenna or transmitter.

Warning

At 0.8 W transmitted power and a distance of 16.1 inches (41 cm) from the antenna, the maximum power density calculated was 0.6 mW/cm^2. Install the antenna at least 16.1 inches (41 cm) from the general public. Maintenance personnel must remain at least 7.5 inches (19 cm) from antenna when system is operating.

Warning

Altering the AI1422 Half-Frame Reader's stated power output of 0.8 W will result in violation of the health limits established for this product.

The data confirms that the TransCore AI1422 Half-Frame Reader System effectively meets OSHA requirements and thus does not represent an operating hazard to either the general public or maintenance personnel.

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Before You Begin

Chapter 1

Before You Begin

The AI1422 Half-Frame Reader User Guide provides information necessary for interfacing the AI1422 Half-Frame Reader System to a host computer system.

Purpose of This Guide

This user guide provides information for interfacing the AI1422 Half-Frame Reader System with a host processor system, also called a host computer system. This guide provides on-site test procedures useful in troubleshooting any problems encountered after installation. Command codes, which allow the user to configure the reader system for communicating with the host computer, are discussed as is ASCII character conversion to TransCore 6-bit character codes.

Intended Audience

The intended audience for the *AI1422 Half-Frame Reader User Guide* is engineers and technicians. These people are involved in the design, specification, and installation of AI1422 Half-Frame Reader Systems.

Related Documents

AP4110 Programmer's Guide (available online at http://www.transcore.com/downloads.html. Go to RFID PRODUCTS then USER AND INSTALLATION MANUALS. Choose AP4110 Tag Programmer User Guide from the drop-down menu.)

Guide Topics

This document presents the following information:

Chapter 1 – Before You Begin	Describes the purpose, intended audience, guide topics, related documentation, document conventions, and licensing requirements
Chapter 2 – System Overview	Provides an overview of the AI1422 Half-Frame Reader System's features, options, supported tag descriptions and tag mounting primer, and accessories
Chapter 3 – Interface Connections	Describes the AI1422 Half-Frame Reader System interface connectors and identifies their primary functions

Chapter 4 – System Test Procedures	Provides testing procedures that the user can use to fine-tune the AI1422 Half-Frame Reader System
Chapter 5 – Command Codes	Discusses the firmware command code that are used to configure the AI1422 Half-Frame Reader for communication with a personal computer or other host computer
Chapter 6 – Troubleshooting and Maintenance	Provides troubleshooting indications and maintenance procedures that are used to keep the AI1422 Half-Frame Reader System operating
Appendix A – Character Conversion	Provides TransCore 6-bit-per-character conversions from the standard ASCII character set
Appendix B – Technical Specifications	Provides the product specifications
Appendix C – Diagnostic Command Codes List	Provides a list of the diagnostic command codes
Appendix D – Cyclic Redundancy Check Description	Provides an outline of the cyclic redundancy check algorithm used in the AI1422 software

Typographical Conventions

Table 1-1 lists the conventions used in this manual.

Table 1-1 Typographical Conventions

Convention	Indication
	This procedure might cause harm to the equipment and/or the user.
	Concerns about a procedure
`Code`	Code, including keywords and variables within text and as separate paragraphs, and user-defined program elements within text appear in courier typeface.
Dialog Box Title	Title of a dialog box as it appears on screen
Function	Start with the characters, G4, and are in mixed case with no underscores, and include parentheses after the name, as in G4FunctionName().
Menu Item	Appears on a menu. Capitalization follows the interface.

Table 1-1 Typographical Conventions (continued)

Convention	Indication
Note	Auxiliary information that further clarifies the current discussion. These important points require the user's attention. The paragraph is in italics and the word Note is boldface.
NUL	Zero-value ASCII character or a zero-value byte
NULL	Zero-value pointers. Null-terminated string refers to strings of printable ASCII characters with a zero-value byte placed in memory directly after the last printable character of the string.

Licensing Requirements

To operate a radio frequency (RF) system in a given country, the user must first obtain permission from the regulatory agency that controls radio operations in that country. Most countries require type and safety approval, as well as licensing for RF transmitters. Users in all countries should check with the appropriate local authorities for licensing requirements.

U.S. Licensing

This AI1422 Half-Frame Reader System requires an FCC Part 90 license to operate in the U.S. The authorized frequency bands in the U.S. are 902 to 904 MHz and 909.75 to 921.75 MHz.

The user is responsible for filing the FCC license according to FCC regulations. Access the FCC Web site at www.fcc.gov/Forms/Form601/601.html or at wireless.fcc.gov/index.htm?job=online_filing to obtain additional information concerning licensing requirements.

Note: *The FCC ID is FIH AI142205618.*

An FCC license provides the user with the legal authorization to operate the RFID systems on the licensed frequencies at the site specified in the license. Only an authorized installer or service technician can set the frequency for the AI1422 Half-Frame Reader System to that specified in the FCC site license.

The FCC license also provides the user with protection and authorization to maintain the system should any other RFID be used in the licensed area after the AI1422 Half-Frame Reader System is installed.

2

System Overview

Chapter 2

System Overview

The AI1422 Half-Frame Reader System is a microprocessor-controlled, single-antenna unit that uses a unique communications protocol to interface with vehicle identification (ID) equipment.

System Overview

This reader system uses radio frequency (RF) energy to read data from tags. The AI1422 Half-Frame Reader System then decodes the tag ID information, validates the ID code, and transmits tag data directly to a host processor for real-time data processing and use.

Communications (terminal) programs usually do not provide adequate data processing capability. Your host computer software can be customized to provide the required capabilities.

The AI1422 Half-Frame Reader System consists of the AI1422 Transponder Interrogator, which consists of a reader and RF module, combined with a TransCore antenna, a TransCore tag, a host processor system, and a power source. Figure 2-1 illustrates a typical reader system configuration.

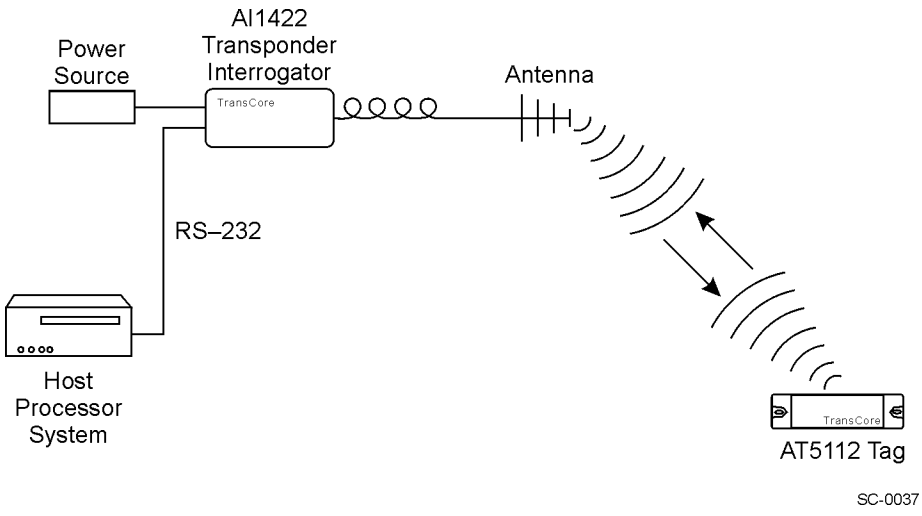

Figure 2-1 Typical Reader System Configuration

AI1422 Half-Frame Reader Features

Table 2-1 presents the features that distinguish the AI1422 reader models.

Table 2-1 AI1422 Half-Frame Reader Features

Reader Model	Transmit Frequency (MHz)	Power Source	Panel Markings Color	Connectors DB25 (RS-232)	# of Characters/ Baud Rate	Hand-shakes	Panel Ground Studs
10-1422-011*	911.5	8V-35V DC	Blue	Male	3/2400	3	No
10-1422-012*	918.5	8V-35V DC	Blue	Female	3/2400	3	No
10-1422-013*	911.5	8V-35V DC	Black	Female	3/2400	3	No
10-1422-016*	911.5	14V-70V DC	Black	Female	10/9600	3	No
10-1422-019*	911.5	28V-140V DC	Black	Female	10/9600	3	No
10-1422-021	911.5	8V-35V DC	Black	Female	10/9600	3	Yes
10-1422-022	918.5	8V-35V DC	Blue	Male	10/9600	3	Yes
10-1422-023*	911.5	28V-140V DC	Black	Female	10/9600	2	Yes
10-1422-024	911.5	8V-35V DC	Blue	Male	3/2400	3	Yes
10-1422-025	918.5	8V-35V DC	Blue	Female	3/2400	3	Yes
10-1422-026	911.5	8V-35V DC	Black	Female	3/2400	3	Yes
10-1422-027	915.0	14V-70V DC	Black	Female	10/9600	3	Yes
10-1422-028	911.5	28V-140V DC	Black	Female	10/9600	3	Yes
10-1422-029	911.5	28V-140V DC	Black	Female	10/9600	2	Yes
10-1422-030	915.0	8V-35V DC	Blue	Male	10/9600	2	Yes
10-1422-031	911.5	8V-35V DC	Black	Female	10/9600	2	Yes
10-1422-121	911.5	8V-35V DC	Black	Female	10/9600	3	Yes
10-1422-122	918.5	8V-35V DC	Blue	Male	10/9600	3	Yes
10-1422-124	911.5	8V-35V DC	Blue	Male	3/2400	3	Yes
10-1422-125	918.5	8V-35V DC	Blue	Female	3/2400	3	Yes
10-1422-126	911.5	8V-35V DC	Black	Female	3/2400	3	Yes
10-1422-127	915.0	14V-70V DC	Black	Female	10/9600	3	Yes
10-1422-128	911.5	28V-140V DC	Black	Female	10/9600	3	Yes
10-1422-129	911.5	28V-140V DC	Black	Female	10/9600	2	Yes
10-1422-130	918.5	8V-35V DC	Blue	Male	10/9600	2	Yes
10-1422-131	911.5	8V-35V DC	Black	Female	10/9600	2	Yes

Note: *Those AI1422 readers marked with an * are no longer available to order.*

Transponder Interrogator

The transponder interrogator reads 60 bits of user-programmable data in the transponder.

The transponder interrogator is operated in a continuous read mode, and any tag entering its read field has its data automatically read and relayed to the host computer. In many applications this function is implemented by installing the reader on a vehicle with restricted movement, such as a railcar or monorail bus. The tags are imbedded in the roadway at various locations in the vehicle's path. The data read from the tag allows the host computer to assess the vehicle's location and make any appropriate response to that information.

The transponder interrogator is an independent tag decoder that combines a reader and RF source to provide automatic identification and data storage within a single, compact unit. The transponder interrogator includes the following components:

- 19-inch rack-mount design
- Serial input/output (I/O) link
- Real-time clock
- 32K buffer storage in static random access memory (SRAM) with battery backup
- Reader and RF module, combined in one unit

Reader Power Regulation and Filtering

The reader system uses an input voltage ranging from 8V DC to 140V DC. The AI1422 Half-Frame Reader System incorporates a high-performance, DC-to-DC power supply that converts voltage in this range to 13.5V DC. TransCore offers three input voltage options:

Power Supply	Fuse Rating	Maximum Power
8V DC to 35V DC	5.0-amp fuse	45 watts
14V DC to 70V DC	3.0-amp fuse	45 watts
28V DC to 140V DC	1.5-amp fuse	45 watts

Antenna

TransCore has two antennas that can operate with the AI1422 Half-Frame Reader System, the AA3233 Rail Antenna and the AA3234 Light Rail Antenna. The AA3233 Rail Antenna can be used where high shock and vibration conditions exist. The AA3234 Light Rail Antenna can be used for light rail applications that require a low profile for mounting on the carriage of commuter trains and people-mover systems.

Transponders (Tags)

The AI1422 Half-Frame Reader System can use TransCore's half-frame read-only tags (Table 2-2).

Table 2-2 Tags Used with AI1422 Half-Frame Reader

Tag Model Number	Tag Type	Tag Programmer
AT5112	Beam powered transportation tag	AP4110
AT5114	Battery powered transportation tag	AP4110
AT5117	Switch power externally powered signal tag (battery performance)	AP4110
AT5119	Switch power externally powered signal tag (battery performance)	AP4110
AT5412	Beam powered transportation tag	AP4600
AT5414	Dual-frequency battery powered transportation tag	AP4600
AT5415	Beam powered hardened transportation tag	AP4600

When selecting a tag for an application that requires the tag to be placed on the road bed, several design elements need to be kept in mind. The beam powered AT5112 tag will have a shorter footprint than a battery or switch powered tag, and thus the maximum top speed of the vehicle will be less, all other factors equal. However, although the battery tag has an inherently longer footprint, the battery life limitation will require the operating company to replace the tags every 8 to 10 years. Additionally, the presence of the battery and its reactive mass reduces the reliability of the tag, particularly when the tag is placed near high shock or vibration locations such as switches.

For practical purposes, the switch powered tags have RF characteristics similar to battery tags, and the tags are powered by inductive power derived from railway switch power.

The advantage of the AT5412, AT5414, or AT5415 tag over the AT5112 tag is that the AT5412, AT5414, and AT5415 tags are programmed via an RF link and thus have no programming plug, The contact-programmed tags are reliable, however, the programming plug can be a source of tag failure if the plug is not properly inserted after customer programming. The absence of of a programming plug means that the tag is a completely factory-sealed product and has greater reliability. Presently, TransCore does not offer a battery tag or a switch powered tag that is programmed by means of an RF link.

Tag Mounting

All of the tags listed in Table 2-2 the tags must be mounted on a flat metal plate. The internal antennas of these tags are tuned for the backplane of the tag to be in contact with a flat metal surface. This metal surface does not need to be extended beyond the

outer dimensions of the tag, and having a larger metal surface will not affect the immediate performance of the tag.

Metal located in the immediate vicinity of the tag, that is, to the sides of the tag or above the tag can affect the tag's performance. Metal surfaces or objects should not be placed closer than 1 inch (2.5 cm) to the side edges of the tag to ensure that the tag's antenna tuning remains within design criteria. Metal placed above the tag can cause shadowing of the RF beam, both in the incident and return directions, and should be avoided. The only exception to this rule would be metal placed for the purpose of effecting the read range of the tag or footprint of the system, and the placement of such metal should be done with careful planning and testing to ensure proper system performance. With battery powered tags, the arrangement of intentional metallic obstructions may be the best way to limit the broad footprint of these tags, as well as improve the repeatability of the TLS signal with respect to its absolute position relative to the tag. These tag mounting details would need to be made *by the customer* on the basis of each customer's overall system design and requirements. Keep in mind that metal placed too close in proximity to the tag will affect the tag's antenna tuning, and may unintentionally affect principal design parameters such as VSWR or the impedance match of single paths internal to the tag, to name a few examples.

Antenna-to-Tag Centerline Alignment

For best performance mount tags so that the centerline of the tags and the centerline of the reader antennas are within ±2.9 inches (±7.5 cm) of each other (Figure 2-2).

Antenna-to-tag Distance

Many installations have been installed with a nominal 11.8-inch (30-cm) distance from the backplane of the reader antenna to the back edge of the tag (Figure 2-2).

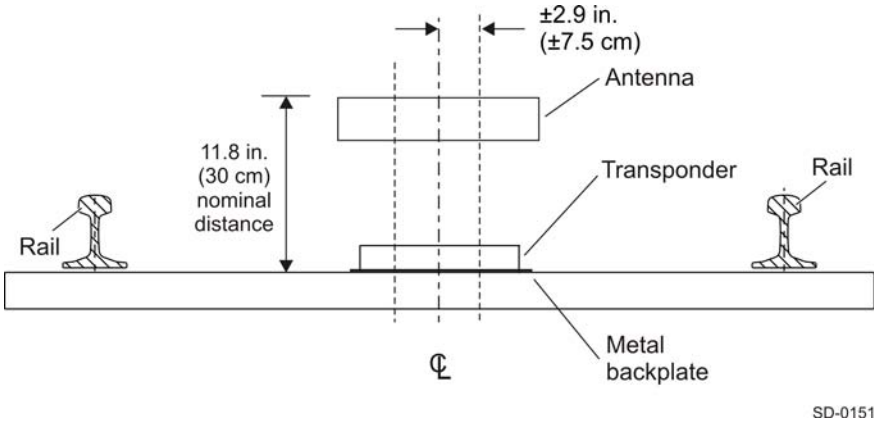

Figure 2-2 Antenna-to-Tag Centerline Tolerance

3

Interface Connections

Chapter 3

Interface Connections

This chapter describes the interface connections and their primary functions.

Description of AI1422 Half-Frame Reader System

Because the AI1422 Half-Frame Reader System combines a reader and radio frequency (RF) module into a single unit, you must connect the following items to the system: the external DC power, the customer input/output (I/O), the main and auxiliary RS–232 interfaces, and the antenna. These interface connectors are located on the AI1422 Half-Frame Reader System front panel as shown in Figure 3-1 and Figure 3-2.

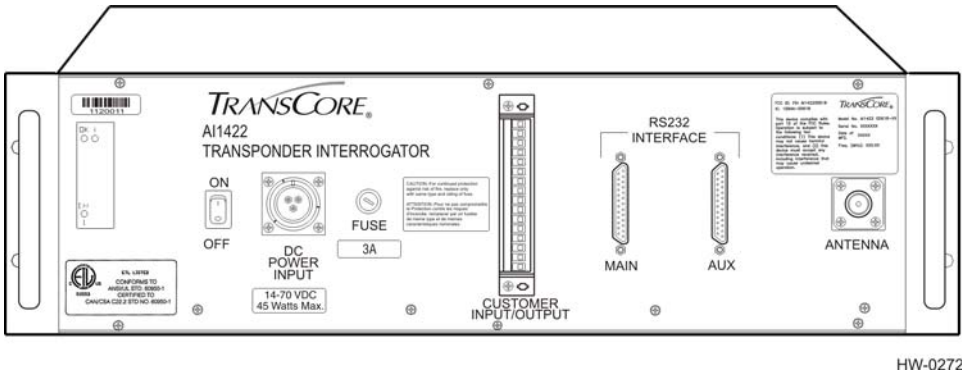

Figure 3-1 Sample Front Panel of a Legacy AI1422 Transponder Interrogator

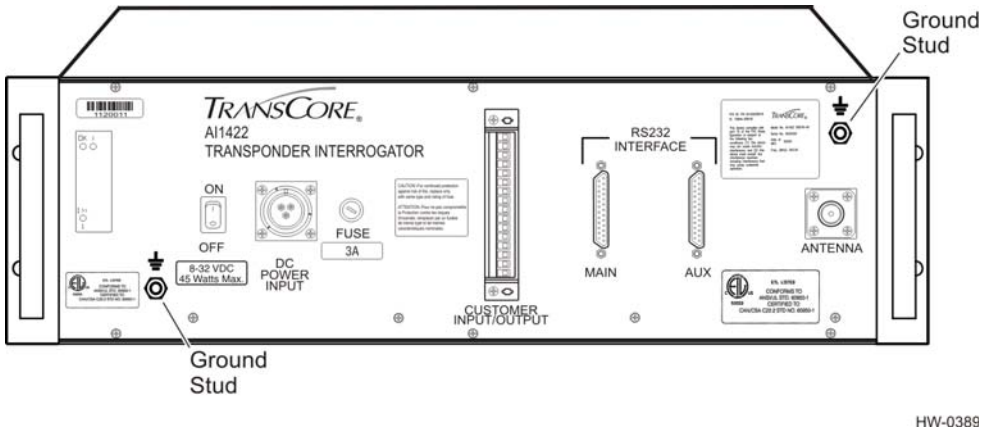

Figure 3-2 Sample Front Panel of a Redesigned AI1422 Transponder Interrogator

Antenna Interface

Attach the antenna cable directly to the antenna interface on the front panel of the AI1422 Half-Frame Reader System. The antenna cable length depends on the installation.

Main RS–232 Interface

The main RS–232 interface is a standard DB25 plug connector used with a host processor. During operation, a host processor system uses the reader system functions in real-time operating mode. In real-time mode, tag IDs are read and passed on to the host processor. Figure 3-3 illustrates the RS–232, DB25 plug connector pin-outs.

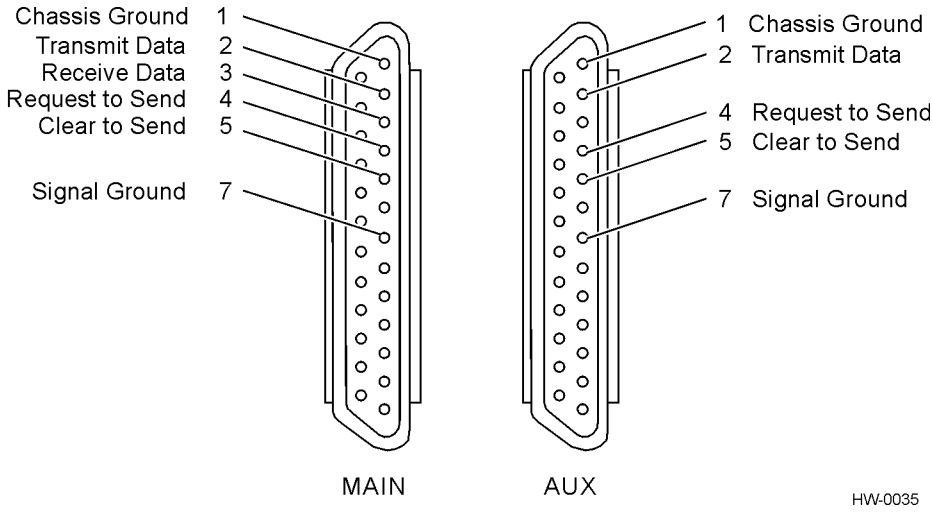

Figure 3-3 RS–232, DB25 Interface Connector Pin-outs

Aux RS–232 Interface

The auxiliary RS–232 interface is used as a backup monitoring system to the main RS–232 interface. The auxiliary interface monitors data from the transponder interrogator. The auxiliary RS–232 interface is a standard DB25 plug connector. This port is not wired to receive data and cannot accept commands.

Customer I/O Interface

A mating connector for the customer I/O interface is supplied with each unit. This connector allows a screw terminal, point-to-point wiring interface. Figure 3-4 shows the pin-outs on the customer I/O interface connector.

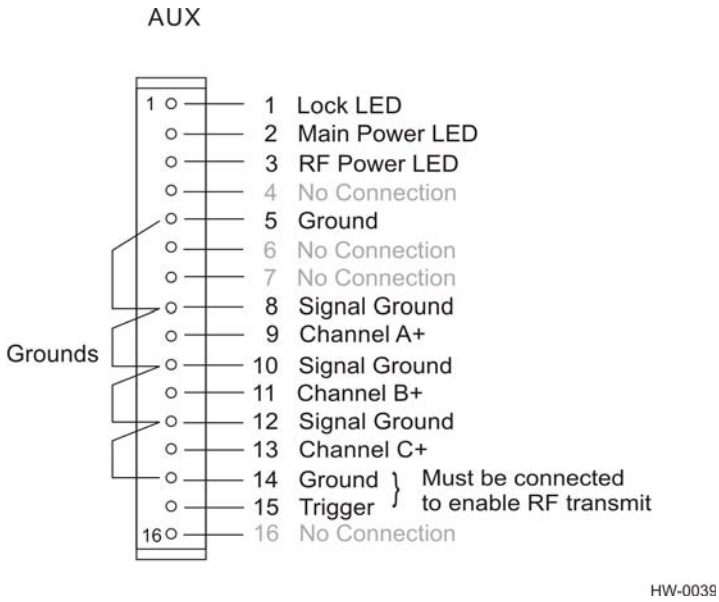

Figure 3-4 Customer I/O Interface Pin-outs

The customer I/O interface connector contains the lock light-emitting diode (LED), main power LED, RF power LED, the trigger signals, and channels A, B, and C.

Lock LED

The transistor-transistor-logic (TTL) lock signal shows the presence of a tag. The lock signal goes active high when a valid tag is in the RF field of the antenna and may be connected to an LED for monitoring purposes.

The Lock LED output is the Q output of a CD4538A one-shot, with a 300-Ohm, 0.25-watt (W) resistor in series. The V_{cc} is 5 volts (V).

Main Power LED

The TTL main power signal goes active high when the ON/OFF switch on the front panel is switched to on. The switch is connected to +5V through a 300-Ohm resistor.

RF Power LED

The TTL RF power LED goes active high when the reader system is configured for the RF power to be on and the ON/OFF switch is set to ON. The switch is connected to +12V through a 1000-Ohm, 0.25-W resistor and may be connected to a LED for RF power monitoring purposes.

Trigger Signals

The trigger connection turns on the RF power when a ground is applied and the AI1422 Half-Frame Reader System has been programmed with the *RF Follows Trigger* command (!642).

Channels A, B, and C

The analog intermediate frequency channel A, B, and C signals represent the three channels generated by the AI1422 Half-Frame Reader System. These channels can be used to measure tag signal quality.

Power Connection

The power connector on the front panel of the AI1422 Half-Frame Reader System is a panel mount circular connector of type Cannon CA 3100 E16-10P-F80-T12.

4

System Test Procedures

Chapter 4

System Test Procedures

This chapter provides testing procedures that will help you fine-tune your reader system and test basic operation, measure radio frequency (RF) power, measure system noise, read tags, and monitor the system.

Required Tools and Equipment

The following tools and equipment are required:

- 50-ohm, 5-watt (W) load (N-type connector)
- Personal computer (PC) with terminal emulator software
- Appropriate power source for your reader
- Digital multimeter
- RF power meter
- 100 MHz oscilloscope
- Antenna, cable, and connectors

Testing Basic Operation

To test the system operation, configure the reader system as follows

CAUTION

The following procedures will cause RF power to be turned on and off at various times. Do not operate the system without a 50-ohm, 5-W load attached to the RF output. When any RF cable is disconnected, the associated RF power measurement unit must be turned off.

1. Connect a 50-ohm, 5-W load (termination) to the antenna interface located on the front panel of the reader system.
2. Configure a terminal emulator (a PC using communications software) to 2400 or 9600 baud, no parity, 8 data bits, and 1 stop bit.
3. Connect the emulator to the main RS–232 interface located on the front panel of the reader system.
4. Switch off the ON/OFF switch located on the front panel of the reader system.

5. Connect a power source to pins A (+) and B (-) on the DC power input front panel connector (Figure 4-1).

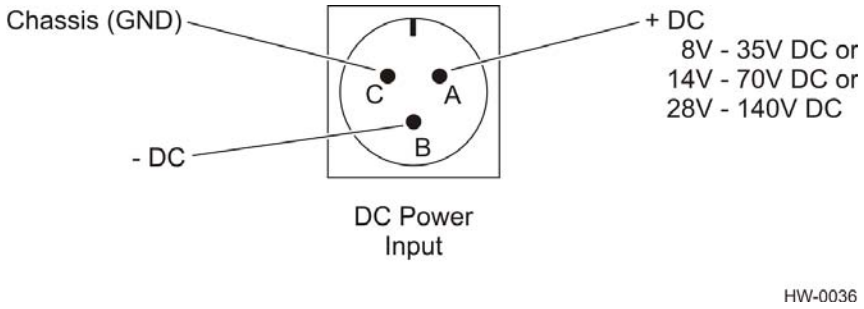

Figure 4-1 Power Source Connections

6. Switch on the ON/OFF switch located on the front panel of the reader system.
7. Type the command `~~CC` (CC must be entered in upper case) and press **`Enter`**.

Note: *For information on entering command codes, refer to Chapter 5, Command Codes.*

8. Type `!22` and press **`Enter`**. The time and date will be returned.

   If the time and date are not received, check communications connections, cycle power, and repeat.

   If the time and date are incorrect, use `!20` and/or `!21` to correct this information, then type the following commands.

!20hh:mm:ss	sets time
!21MM/DD/YY	sets date
!642	sets RF to follow the trigger
!41	enables tag reporting

   NOTE*: !41 command should be used in diagnostic mode only. Do not use in normal system operation.*

   The entered command and `!Done` response will be returned after each properly executed command.

Measuring RF Power

To measure the RF power

1. Set the ON/OFF switch located on the front panel of the reader system to off.
2. Connect an RF power meter of known accuracy to the antenna interface on the front panel of the reader system (Figure 4-2). Power measured at the antenna connector should be 0.8 W (29 dBm).

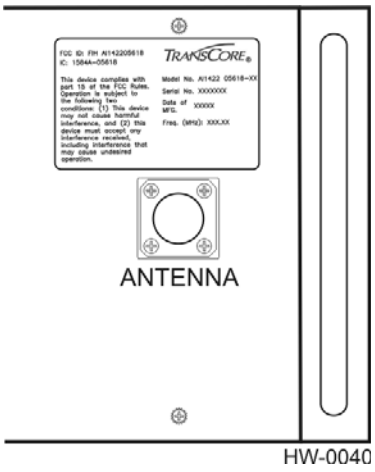

Figure 4-2 Antenna Interface on Front Panel

Caution

Some RF power meters have input power restrictions, and 0.8 W can severely damage the RF meter if applied directly. Use supplemental attenuators of known accuracy with these types of meters and add the attenuation amount to the resulting RF power measurement.

3. If a cable is used with the power meter, the cable loss must be determined by measuring all cables with an RF power meter of known accuracy. Calculate the resultant RF power levels using the formula dB = 10_{log} P in/P out. Add this loss to the meter reading to determine the actual RF power output.
4. Set the ON/OFF switch located on the front panel of the reader system to on.
5. Repeat steps 6 through 8 under the section "Testing Basic Operation" on page 4-3 to configure the unit to operating conditions.The RF power measurement should read greater than 0.8 W.

   Example of RF power measurement with a 645-mW meter reading using a cable:

10_{log} 645	+28.1 dBm
Test cable loss	0.9 dB
Total	+29.0 dBm = 0.8 W

Measuring System Noise

With the equipment configured the same as for the RF power measurement test described above, connect a 100 MHz oscilloscope to the customer I/O interface according to the parameters listed in Table 4-1.

Table 4-1 System Noise Test Parameters

Channel	Pins
A	8 (ground) and 9
B	10 (ground) and 11
C	12 (ground) and 13

Figures 4-3 through 4-5 depict waveforms generated at selected channels, as shown by an oscilloscope.

Figure 4-3 illustrates the desired waveform generated during normal operation with a valid tag in the reader field.

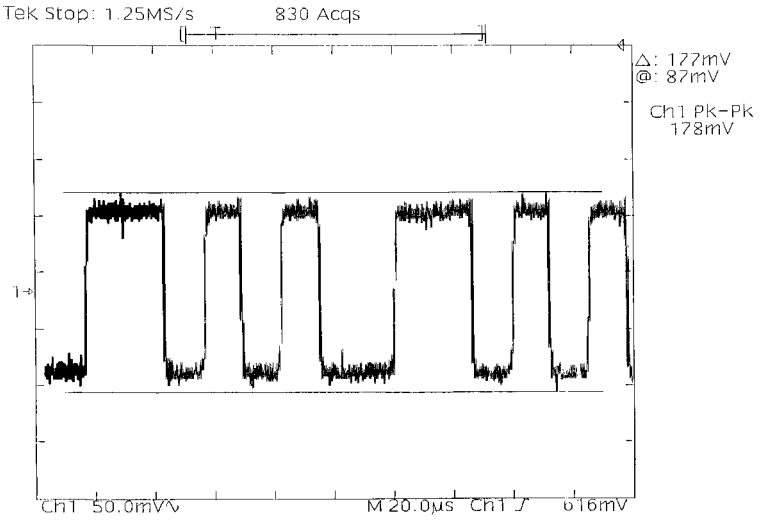

Figure 4-3 Typical Waveform with a Tag in the Reader Field

Figure 4-4 depicts typical quiescent noise levels with the RF connector configured with a 50-ohm, 5-W terminator. Quiescent noise levels vary from unit to unit with channel C having the most representative noise level.

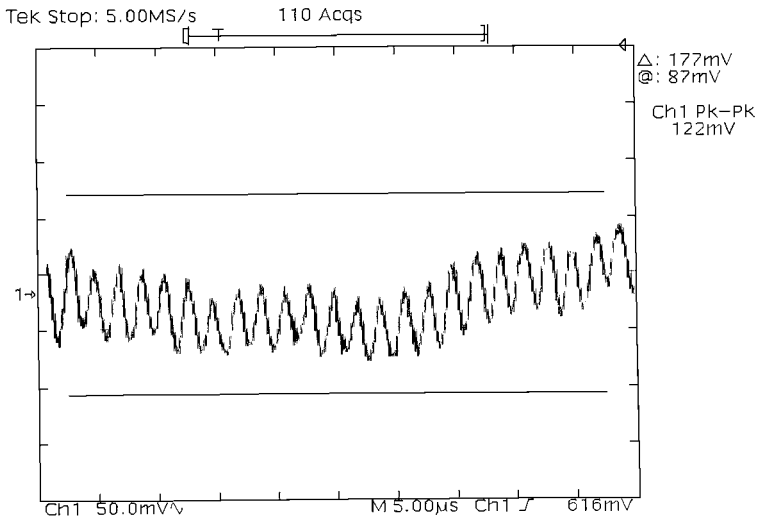

Figure 4-4 Typical Quiescent Noise Waveform

Figure 4-5 shows the typical beat frequency interference waveform caused by a similar frequency interrogator system connected to an antenna in proximity to the system under test.

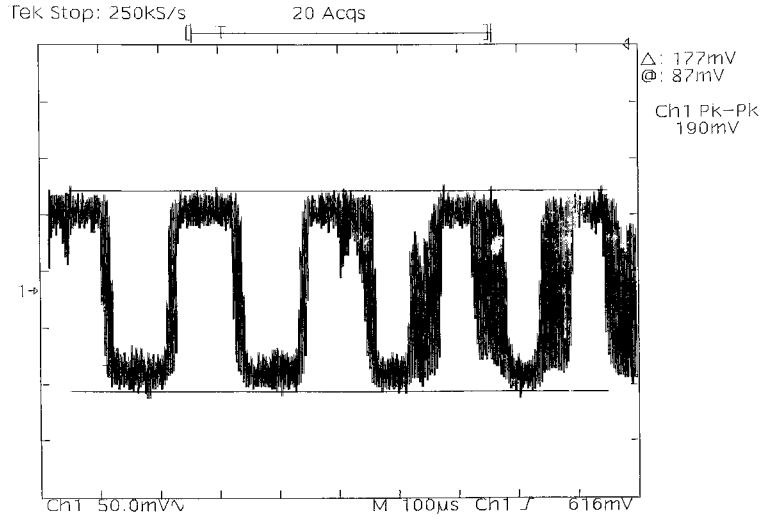

Figure 4-5 Typical Beat Frequency Interference Waveform

Reading the Tag

To verify that the AI1422 Half-Frame Reader System is correctly reading tags

1. Switch the ON/OFF switch located on the front panel of the reader system to off.
2. Using your own cable, connect the laptop PC to the reader system at the main RS–232 interface.
3. Connect the antenna to the antenna interface on the front panel of the reader system.
4. Connect three customer-supplied light-emitting diodes (LED) between the ground pin and lock LED, the ground pin and the main power LED, and the ground pin and the RF power LED. All of these pins are located on the customer I/O interface on the front panel of the reader system.
5. Set the ON/OFF switch located on the front panel of the reader system to on.
6. Connect a jumper between pins 14 (ground) and 15 (trigger) on the customer I/O interface to trigger the RF on (Figure 3-4 on page 3-5).
7. Monitor the LEDs on the box and verify that the main power LED and the RF power LED are lit.
8. Position a programmed TransCore half-frame rail tag with a backplate within 2 to 3 feet (0.6 to 0.9 m) of the antenna. No other tag can be in this 2 to 3 foot (0.6 to 0.9 m) area during this test.
9. Verify that the lock LED is lit and that the PC is acquiring the tag data.

Note: *If the !41 command was issued prior to this test, the PC will be receiving a continuous stream of tag data. If the !41 command was not issued, the reader responds with only one response. The Lock LED remains lit as long as there is a tag in the field, but only one response is forthcoming unless the !41 command has been issued.*

10. Remove the tag from the antenna field. The PC should stop reading the tag data.
11. Disable the trigger by disconnecting the jumper.
12. Set the on/off switch located on the front panel of the reader system to off.

Note: *Repeat this test several times. Each time, the lock LED should be lit and the PC should be reporting the tag data.*

5

Command Codes

Chapter 5

Command Codes

This chapter describes the default and diagnostic command codes that enable you to develop host computer programs to control the functions of the AI1422 Half-Frame Reader System.

Default Command Codes

The default command codes enable communications between the host computer and the reader system. These codes, also referred to as the communications protocol, are in a binary format. TransCore strongly recommends that a person with software writing capabilities write this communications protocol.

The transponder identification (ID) can be 3 or 10 bytes, which corresponds to 2400 or 9600 baud, respectively. These bytes are 6-bits coded. See Appendix A, "Character Conversion," of this user guide.

Asynchronous Reader Data Telegram

The reader system sends a data telegram in 8-bit RS-232 to the front panel connectors when it reads a unique tag ID. The message format is as follows:

```
<7EH><7EH><01H><transponder count><transponder ID<CR>
```

Table 5-1 presents the field descriptions.

Table 5-1 Asynchronous Reader Telegram Fields

Field	Description
<7Ex>	The start of the message is an 8-bit byte, hex value 7#. This character translates to a standard ASCII tilde (~) character. This pair of characters, along with the <01x>, denotes the start of the data telegram.
<7Ex>	The second tilde (~)
<01x>	An 8-bit frame-start character. This character denotes that this is a reader data telegram.
<Transponder Seen Count>	After power-up, this 8-bit count begins on hex 01 and is updated each time a tag with a specific ID moves out of, then back into the RF field. This field is useful in determining whether a train has multiple tag reads of a given ID due to a change in the train's direction.

Table 5-1 Asynchronous Reader Telegram Fields

Field	Description
<Tag ID>	Ten 8-bit standard ASCII bytes report the ID data programmed into the tag. The data within the tag is 6-bit ASCII (see Appendix A). The reader translates this data into standard 8-bit ASCII, so that a terminal emulator sees this as 10 real characters, which were programmed into the tag using the tag programmer's #204 command.
<CRC>	An 8-bit cyclical redundancy check (CRC), starting with the 01x, and including the Seen Count and the Tag ID data. See Appendix D for a description of the CRC algorithm employed.
<CR>	A carriage return ends the telegram. No line feed is included.

Health Status Request

You will need to write a script file to download the following binary string for the health status request.

Note: *When entering data via script files, use meta keys, which are available with most terminal emulators, to reduce the data flow rate to the AI1422 reader. These meta keys can ensure that all data characters sent from a host computer is received intact by the AI1422 reader processor.*

```
<7EH><7EH><40><CR>
```

The response is

```
<7EH><7EH><02H><Transponder count><host computer
telegrams-bad CRC><incomplete host telegram>
<Reserved><Reserved><Reserved><CR>
```

Retransmit Request

You will need to write a script file to download the retransmit request.

```
<7EH><7EH><42H><CR>
```

The response is

```
<7EH><7EH><01H><transponder count><transponder ID><CR>
```

Diagnostic Command Codes

Diagnostic commands are used to check or fine-tune the reader system.

Diagnostic Command Code Syntax

Unlike default command codes that require a script file, diagnostic codes are typed by the user. The general syntax of diagnostic commands is to begin with an exclamation character, !, followed by the command code and a list of parameters. No spaces should

be between characters, and the command is sent by pressing **Enter** or carriage return **<CR>**.

As characters are typed, they are automatically displayed on the terminal (except for the ~~CC command). As soon as the command is terminated with **Enter** or a **<CR>**, the reader system responds to the command as follows:

`!Done` command recognized and accepted

or

`!Error` command not recognized

The normal response is `!Done.` Other responses, for example, the time/date response, provide a description of the entry made or command completed.

The reader system operates using two distinct command sets. The first command set contains the system default commands when the system is turned on. The second command set contains diagnostic and other fine-tuning codes.

Diagnostic Command Code Listing

The following commands are used for diagnostics or to fine-tune the reader system.

Escape Command

`!~~CC`

Entering the escape command disables the reader system default command codes and allows the reader system to accept the other diagnostic and fine-tuning command codes (CC must be entered in upper case).

The response is

No response is returned

Baud Rate Select

`!100x`

Command `!100x` selects the baud rate, where x = 0 to 6:

0 = 110 baud
1 = 300 baud
2 = 1200 baud
3 = 2400 baud
4 = 4800 baud
5 = 9600 baud *(factory setting)*
6 = 19.2 kbaud

The response is

!Done or !Error

Note: *The !Done response is issued at the setting that existed before invoking the new command. All subsequent communications will be at the new baud rate.*

Set the Time in the Real-Time Clock

`!20hh:mm:ss`

where

hh = hours (00–23)

mm = minutes (00–59)

ss = seconds (00–59)

The response is

!Done or !Error

Note: *The time must be entered exactly as shown with no spaces between characters and colons as delimiters. All entries use decimal characters 0 through 9.*

Set the Date in the Real-Time Clock

`!21MM/DD/YY`

where

MM = month (01–12)

DD = day (01–31)

YY = year (00–99)

The response is

!Done or !Error

Note: *The date must be entered exactly as shown with no spaces between characters and with forward slashes (/) as delimiters. All entries use decimal characters 0 through 9.*

Display Time and Date

`!22`

where

hh = hours (00–23)

mm = minutes (00–59)

ss = seconds (00–59)

dd = hundredths of seconds

MM = month

DD = day

YY = year

The response is

!hh:mm:ss.dd MM/DD/YY

or

!Error

Note: *There are two spaces between the time and the date.*

Disable Transmit All Tag ID Codes

`!40`

Command `!40` disables command `!41`.

The response is

!Done or !Error

Transmit All Tag ID Codes

`!41`

Command `!41` transmits to the host computer all tag IDs received by the antenna.

The response is

!Done or !Error

Note: *This command is to be used for diagnostic purposes only.*

Report Firmware Version Number

`!505`

Command `!505` requests a report on the reader's installed firmware version.

This command displays one of the following three messages:

`AI1422 firmware version 1.00 part number 11523-00`

(This response corresponds to the 10-character/2-handshake version of the AI1422 reader)

`AI1422 firmware version 1.00 Copyright 1999 Intermec Amtech`

(This response corresponds to the 10-character/3-handshake version of the AI1422 reader)

`Model AI1403 Ver 1.00`

(This response corresponds to the 3-character/3-handshake version of the AI1422 reader)

Disable RF

`!640`

Command `!640` disables the RF output.

The response is

!Done or !Error

Enable RF

`!641`

Command `!641` enables the RF output.

The response is

!Done or !Error

RF Follows Trigger

`!642`

Command `!642` switches RF power on continuously.

The response is

!Done or !Error

Note: *This command is for diagnostic purposes only.*

Software Reset

`!662`

Command `!662` forces a software reset.

The response is

No response is returned and the reader is reset to data mode.

Return to Default Command Codes

`!663`

Command `!663` returns the host computer to the default command codes.

No response is returned

6

Troubleshooting and Maintenance

Chapter 6

Troubleshooting and Maintenance

This section lists routine diagnostic procedures for troubleshooting an improperly working reader system and maintenance procedures to keep the AI1422 Half-Frame Reader System operating correctly.

Required Tools and Equipment

The following tools and equipment are required:

- 50-ohm, 5-watt (W) load (N-type connector)
- Personal computer (PC) with terminal emulator software
- Appropriate power source for your reader
- Digital multimeter
- RF power meter
- 100 MHz oscilloscope
- Antenna and cable
- Phillips head screwdriver

Troubleshooting

No loop-back mode to restore defaults, such as baud rate, means that troubleshooting is required.

Failure Modes

No Communication – To determine if there is a problem in the communications hardware, the following two commands should be repeated together for testing purposes:

!~~CC escape to diagnostic mode

!22 display time and date

If functioning properly, the time and date will be displayed after the second command, which means that the reader is communicating. If the reader is not functioning properly, then perform the following checks.

- Does the AI1422 Half-Frame Reader System have adequate power? If not, ensure reader has 13.5V DC ±0.5V DC.

- Is the main power switch on? If not, switch it on.
- Is the main power switch light-emitting diode (LED) lit? If not, turn on power switch.
- Is the front panel fuse blown? If so, replace it with properly rated slo-blo fuse (see front panel label for fuse rating).
- Is the reader's DC-DC converter functioning? If so, the OK LED on upper left corner of front panel will be lit.
- Are you using a null modem cable connection? If not, switch to a null modem connection.
- Have you set the correct baud rate? If an incorrect baud rate is suspected, select and send each baud rate in turn, using the !100x Baud Rate Select command, and wait for a response.

Unit Will Not Read Tags

The suggestions listed here assume that the user has already verified proper serial communications, and the command `!305` has been entered successfully to enable real-time transmission to the host computer. If RF POWER LED, which is recommended for customer I/O connector, is lit, the indication is that the AI1422 is querying for tags. If the LOCK LED, which is recommended for the customer I/O connector, is lit, the indication is that the reader system is retrieving tag data. If either LED is not lit, then check the following items:

- Verify that the antenna connection is good.
- Verify that the antenna cable is in good condition.
- Verify that a single, known valid tag is in the antenna field.
- Verify that the trigger remains activated and the unit power is on.
- Verify that a tag being alternated with a tag containing different data to avoid uniqueness filtering.

Unit Will Not Retain Settings

If the unit will not retain information, such as time and date stamp or baud rate between power cycles, the internal battery backup has failed and the unit must be returned for repair. Contact TransCore at the telephone number listed at the front of this user guide.

Maintenance Procedures

1. If your AI1422 Half-Frame Reader has the optional rear panel installed, remove it by removing the four mounting screws (Figure 6-1).

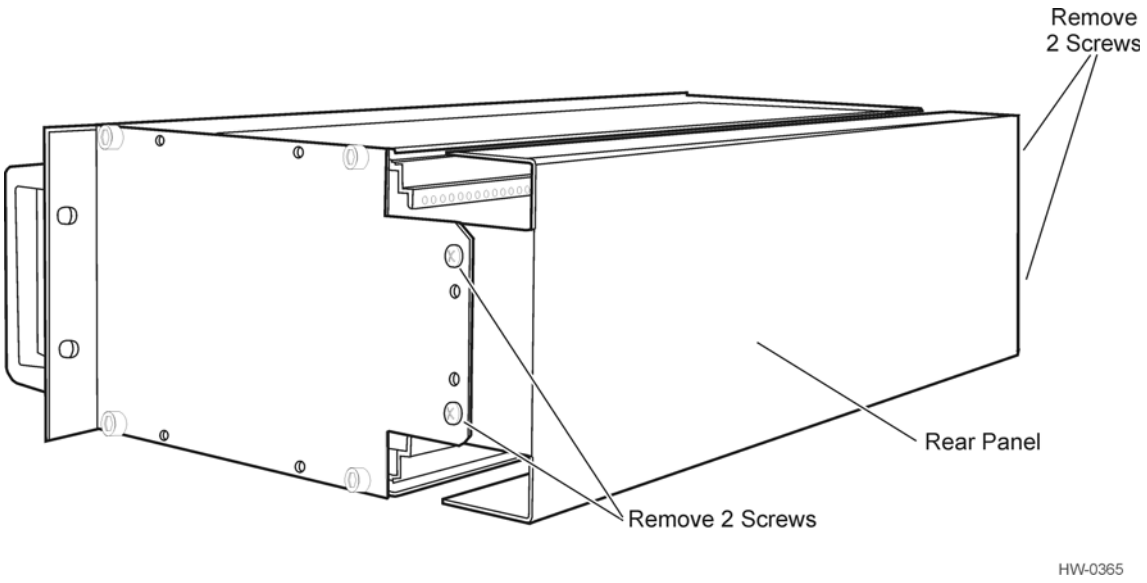

Figure 6-1 Locations of Screws on Optional Rear Panel

2. Connect a jumper between pins 14 (ground) and 15 (trigger) on the customer input/output (I/O) connector to turn on the RF power. Figure 3-4 in Chapter 3 shows the location of pins 14 and 15.
3. Connect a voltage output meter to pins 20 (+) and 23 (-) at the back of the Melcher DC-DC converter. Figure 6-2 shows the location of pins 20 and 23.
4. Loosen retaining nut that secures R1 (Figure 6-2).
5. Adjust the R1 knob to obtain 13.5V DC ±0.5V DC.
6. Retighten retaining nut on R1 and ensure that the voltage is set at 13.5V DC ±0.5V DC.

   If voltage setting changed from 13.5V DC ±0.5V DC, repeat steps 2 through 6.

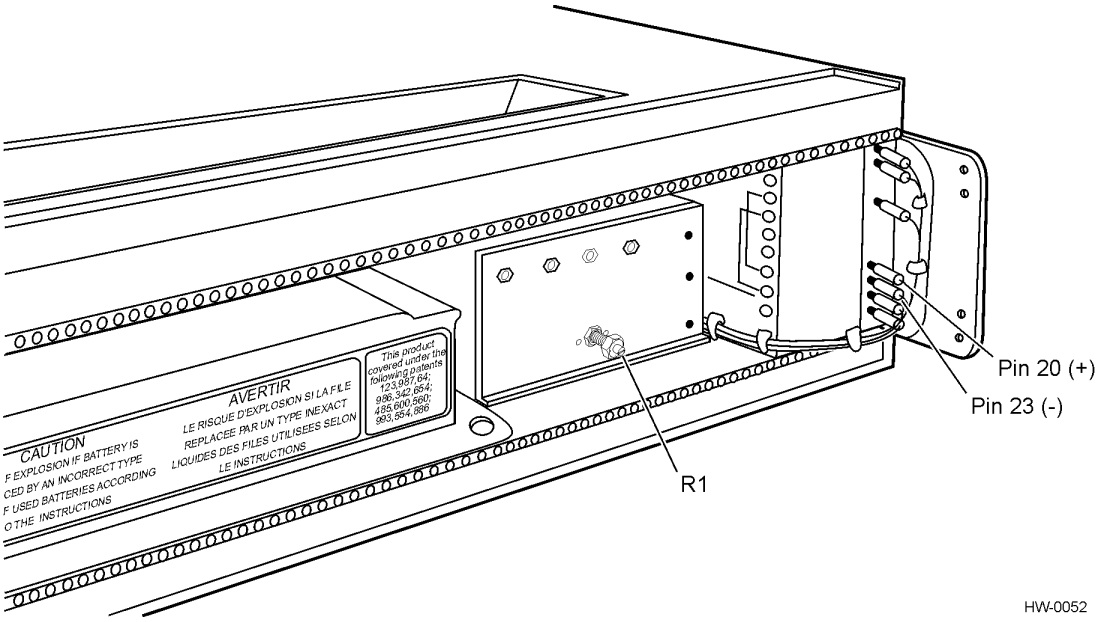

Figure 6-2 Locations for DC Voltage Adjustment Measuring RF Power

7. Replace optional rear panel and tighten Phillips head mounting screws when finished with troubleshooting/maintenance procedures.

Except for the slo-blo fuse in the front panel of the unit, there are no user-serviceable parts in the AI1422 Half-Frame Reader System.

A

Character Conversion

Appendix A
Character Conversion

Table A-1 lists the TransCore 6-bit-per-character conversion from the standard ASCII character set.

Table A-1 TransCore 6-Bit-Per-Character Conversion

spc	000000	6	010110	L	101100
!	000001	7	010111	M	101101
"	000010	8	011000	N	101110
#	000011	9	011001	O	101111
$	000100	:	011010	P	110000
%	000101	;	011011	Q	110001
&	000110	<	011100	R	110010
'	000111	=	011101	S	110011
(	001000	>	011110	T	110100
)	001001	?	011111	U	110101
*	001010	@	100000	V	110110
+	001011	A	100001	W	110111
,	001100	B	100010	X	111000
-	001101	C	100011	Y	111001
.	001110	D	100100	Z	111010
/	001111	E	100101	[	111011
0	010000	F	100110	\	111100
1	010001	G	100111	]	111101
2	010010	H	101000	^	111110
3	010011	I	101001	_	111111
4	010100	J	101010		
5	010101	K	101011		

B

Technical Specifications

Appendix B
Technical Specifications

Table B-1 lists the specifications of the AI1422 Half-Frame Reader System.

Table B-1 AI1422 Half-Frame Reader System Specifications

Specification	Description
Size	19.0 x 5.25 x 9.0 in (48.3 x13.34 x 22.9 cm)
Weight	12.0 lb (5.4 kg)
Operating temperature	+32°F to +158°F (+0°C to +70°C)
Power requirement	8V to 35V DC, 45 watts maximum (5.0 amp fuse required), 14V to 70V DC, 45 watts maximum (3.0 amp fuse required), or 28V to 140V DC, 45 watts maximum (1.5 amp fuse required)
Available frequency range	902–928 MHz
Approved frequency range for Federal Communications Commission and Industry Canada	902.25–903.75 MHz and 910.00–921.50 MHz
Receiver RF bandwidth	≅1.2 MHz
Receiver sensitivity	-48 dBm
Transmitter frequency stability	±5.0 ppm over operating temperature range
Transmitter RF power	0.8W ±0.1W
Communications port	RS–232, 110 to 19,200 baud
Other features	Real-time calendar clock Two grounding studs on front panel

C

Diagnostic Command Codes List

Appendix C

Diagnostic Command Codes List

Table C-1 lists the diagnostic commands and their functions.

Table C-1 Diagnostic Commands

Command	Function
!~~CC	Escape (CC must be entered in upper case)
!100x	Baud rate select
!20hh:mm:ss	Set the time in the real-time clock
!21MM/DD/YY	Set the date in the real-time clock
!22	Display time and date
!40	Disable transmit all tag ID codes
!41	Transmit all tag ID codes
!505	Report firmware version number
!640	Disable RF
!641	Enable RF
!642	RF follows trigger
!662	Software reset
!663	Return to default command codes

D

Cyclic Redundancy Check Description

Appendix D

Cyclic Redundancy Check Description

The cyclic redundancy check (CRC) used in the AI1422 Half-Frame Reader is detailed here.

```
unsigned char generateCrc(unsigned char newByte, unsigned char newCrc)
{
   int i;
   unsigned char carryOld = 0;
   unsigned char carryNew = 0;

   for (i = 8; i > 0; i--)
   {
;                                  Following 3 stmnts imitate "rotate left
                                   through carry" of data byte
      carryNew = (newByte >> 7);   Shift Right 7, (high bit remains)
      newByte <<= 1;               Left shift by 1
      newByte |= carryOld;         Or the carry bit (previous high bit) into new-
                                   Byte low bit
;
      carryOld = carryNew;         put carryNew into carryOld
;
;                                  Following 3 stmnts imitate "rotate left
                                   through carry" of CRC
      carryNew = (newCrc >> 7);    Get high bit of CRC, put into carryNew
      newCrc <<= 1;                Make room for carry bit in low order of newCRC
      newCrc |= carryOld;          Or the carry bit into newCRC
      carryOld = carryNew;         Save the high order bit of CRC

      if (carryNew) newCrc ^= 0x85;If carryNew non-zero, XOR newCRC with 0x85
                                   polynomial
   }

   return newCrc;
}

int main(void)
{
   int i, j;
   unsigned char newStr[5][12] =
   {
      {0x01, 0x21, 'T', 'E', 'S', 'T', ' ', 'T', 'A', 'G', ' ', '1'},
      {0x01, 0x01, 'T', 'E', 'S', 'T', ' ', 'T', 'A', 'G', ' ', '1'},
      {0x01, 0x23, 'T', 'E', 'S', 'T', ' ', 'T', 'A', 'G', ' ', '1'},
      {0x01, 0x24, 'R', 'I', 'C', 'H', 'A', 'R', 'D', ' ', '0', '2'},
      {0x01, 0x22, 'R', 'I', 'C', 'H', 'A', 'R', 'D', ' ', '0', '2'}
   };
   unsigned char newCrc = 0x00;
```

```
   for (j = 0; j < 5; j++)
   {
      for (i = 0; i < sizeof(newStr[j]); i++)
      {
         newCrc = generateCrc(newStr[j][i], newCrc);
         printf("0x%02X (%c)\n", newStr[j][i], newStr[j][i]);
      }
      printf("crc: 0x%02X (%c)\n", newCrc, newCrc);
      printf("\n");

      newCrc = 0x00;
   }

}

;Computed CRCs for the previous examples
;               string 1 CRC = 0xAC
;               string 2 CRC = 0xC1
;               string 3 CRC = 0x70
;               string 4 CRC = 0x34
;               string 5 CRC = 0xD5
```