Purpose of This Guide

This user guide is intended for skilled personnel (including trained technicians and engineers) to provide information for initializing the AI1422 Half-Frame Transponder Interrogator.

This guide provides information for interfacing the AI1422 Half-Frame Transponder Interrogator with a host processor or computer system, on-site test procedures useful in troubleshooting, AI1422 command codes, and information on character translation.
Information in this document is subject to change and does not represent a commitment on the part of TransCore, LP.

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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/cm²) 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/cm² of:

<table>
<thead>
<tr>
<th>Frequency (in MHz)</th>
<th>Power Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500</td>
<td>0.61 mW/cm²</td>
</tr>
</tbody>
</table>

Thus, the maximum permissible exposure for general population/uncontrolled exposure at 915 MHz is 0.61 mW/cm². The power limit is a six-minute average.

The RF power density generated by the Interrogator was calculated using a maximum antenna gain of 12 dBi, equivalent to the antenna gain used in a typical Interrogator 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/cm². 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 Interrogator’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 Interrogator effectively meets OSHA requirements and thus does not represent an operating hazard to either the general public or maintenance personnel.
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 Interrogator 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 Interrogator 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 Interrogator is installed.
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</table>
Chapter 1

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

The AI1422 Half-Frame Transponder Interrogator uses radio frequency (RF) energy to read data from tags. The Interrogator 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 Interrogator consists of the AI1422 Transponder Interrogator, which consists of an interrogator and RF module, combined with a TransCore antenna, a TransCore tag, a host processor system, and a power source. Figure 1 illustrates a typical interrogator configuration.
Interrogator Features

Table 1 presents the features that distinguish the various AI1422 interrogator models.

<table>
<thead>
<tr>
<th>Interrogator Model</th>
<th>Transmit Frequency (MHz)</th>
<th>Power Source</th>
<th>Panel Markings Color</th>
<th>Connectors DB25 (RS-232)</th>
<th># of Characters/Baud Rate</th>
<th>Handshakes</th>
<th>Panel Ground Studs</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-1422-011*</td>
<td>911.5</td>
<td>8V-35V DC</td>
<td>Blue</td>
<td>Male</td>
<td>3/2400</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>10-1422-012*</td>
<td>918.5</td>
<td>8V-35V DC</td>
<td>Blue</td>
<td>Female</td>
<td>3/2400</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>10-1422-013*</td>
<td>911.5</td>
<td>8V-35V DC</td>
<td>Black</td>
<td>Female</td>
<td>3/2400</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>10-1422-016*</td>
<td>911.5</td>
<td>14V-70V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>10-1422-019*</td>
<td>911.5</td>
<td>28V-140V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>10-1422-021*</td>
<td>911.5</td>
<td>8V-35V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-022*</td>
<td>918.5</td>
<td>8V-35V DC</td>
<td>Blue</td>
<td>Male</td>
<td>10/9600</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-023*</td>
<td>911.5</td>
<td>28V-140V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-024*</td>
<td>915.0</td>
<td>8V-35V DC</td>
<td>Blue</td>
<td>Male</td>
<td>3/2400</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-025*</td>
<td>918.5</td>
<td>8V-35V DC</td>
<td>Blue</td>
<td>Female</td>
<td>3/2400</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-026*</td>
<td>911.5</td>
<td>8V-35V DC</td>
<td>Black</td>
<td>Female</td>
<td>3/2400</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-027*</td>
<td>915.0</td>
<td>14V-70V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-028*</td>
<td>911.5</td>
<td>28V-140V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-029*</td>
<td>911.5</td>
<td>28V-140V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-030*</td>
<td>915.0</td>
<td>8V-35V DC</td>
<td>Blue</td>
<td>Male</td>
<td>10/9600</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-031*</td>
<td>911.5</td>
<td>8V-35V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-032*</td>
<td>922.5</td>
<td>8V-35V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-121</td>
<td>911.5</td>
<td>8V-35V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-122</td>
<td>918.5</td>
<td>8V-35V DC</td>
<td>Blue</td>
<td>Male</td>
<td>10/9600</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-124</td>
<td>911.5</td>
<td>8V-35V DC</td>
<td>Blue</td>
<td>Male</td>
<td>3/2400</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-125</td>
<td>918.5</td>
<td>8V-35V DC</td>
<td>Blue</td>
<td>Female</td>
<td>3/2400</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-126</td>
<td>911.5</td>
<td>8V-35V DC</td>
<td>Black</td>
<td>Female</td>
<td>3/2400</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-127</td>
<td>915.0</td>
<td>14V-70V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-128</td>
<td>911.5</td>
<td>28V-140V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-129</td>
<td>911.5</td>
<td>28V-140V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-130</td>
<td>918.5</td>
<td>8V-35V DC</td>
<td>Blue</td>
<td>Male</td>
<td>10/9600</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-131</td>
<td>911.5</td>
<td>8V-35V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-132</td>
<td>922.5</td>
<td>8V-35V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-133</td>
<td>918.5</td>
<td>28V-140V DC</td>
<td>Blue</td>
<td>Male</td>
<td>10/9600</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-134</td>
<td>922.5</td>
<td>8V-35V DC</td>
<td>Blue</td>
<td>Male</td>
<td>3/2400</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>10-1422-135</td>
<td>922.5</td>
<td>8V-35V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>2</td>
<td>Yes</td>
</tr>
<tr>
<td>10-1422-136</td>
<td>922.5</td>
<td>28V-140V DC</td>
<td>Black</td>
<td>Female</td>
<td>10/9600</td>
<td>3</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: AI1422 interrogators 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 interrogator 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 interrogator 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
- Interrogator and RF module, combined in one unit

Interrogator Power Regulation and Filtering

The interrogator uses an input voltage ranging from 8V DC to 140V DC. The AI1422 Half-Frame Interrogator 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 shown in Table 2:

<table>
<thead>
<tr>
<th>Power Supply</th>
<th>Fuse Rating</th>
<th>Maximum Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>8V DC to 35V DC</td>
<td>5.0-amp fuse</td>
<td>45 watts</td>
</tr>
<tr>
<td>14V DC to 70V DC</td>
<td>3.0-amp fuse</td>
<td>45 watts</td>
</tr>
<tr>
<td>28V DC to 140V DC</td>
<td>1.5-amp fuse</td>
<td>45 watts</td>
</tr>
</tbody>
</table>

Antenna

TransCore has two antennas that can operate with the Interrogator 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 Interrogator can only be used with the TransCore half-frame read-only tags listed in Table 3.
Table 3 – Tags Used with Interrogator

<table>
<thead>
<tr>
<th>Tag Model Number</th>
<th>Tag Type</th>
<th>Tag Programmer</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT5112</td>
<td>Beam powered transportation tag</td>
<td>AP4110</td>
</tr>
<tr>
<td>AT5114</td>
<td>Battery powered transportation tag</td>
<td>AP4110</td>
</tr>
<tr>
<td>AT5117</td>
<td>Switch power externally powered signal tag</td>
<td>AP4110</td>
</tr>
<tr>
<td></td>
<td>(battery performance)</td>
<td></td>
</tr>
<tr>
<td>AT5119</td>
<td>Switch power externally powered signal tag</td>
<td>AP4110</td>
</tr>
<tr>
<td></td>
<td>(battery performance)</td>
<td></td>
</tr>
<tr>
<td>AT5412</td>
<td>Beam powered transportation tag</td>
<td>AP4600</td>
</tr>
<tr>
<td>AT5414</td>
<td>Dual-frequency battery powered transportation tag</td>
<td>AP4600</td>
</tr>
<tr>
<td>AT5415</td>
<td>Beam powered hardened transportation tag</td>
<td>AP4600</td>
</tr>
</tbody>
</table>

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, so the maximum top speed of the vehicle must be less, all other factors equal.

The battery tag has an inherently longer footprint, but 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.

The switch powered tags have RF characteristics like battery tags, and the tags are powered by inductive power derived from railway switch power.

The AT5412, AT5414, and AT5415 tags are programmed via an RF link and do not have a programming plug. The absence 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. 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.

Tag Mounting

All the tags listed in Table 3 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 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 based on 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 interrogator antennas are within ±2.9 inches (±7.5 cm) of each other (Figure 2).

**Antenna-to-tag Distance**

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

![Figure 2 – Antenna-to-Tag Centerline Tolerance](image-url)
Chapter 2 – Interface Connections

This chapter describes the interface connections and their primary functions.

Description of AI1422 Half-Frame Interrogator

Because the AI1422 Half-Frame Interrogator combines a interrogator 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 Interrogator front panel as shown in Figure 3 and Figure 4.

Figure 3 – Sample Front Panel of a Legacy AI1422 Transponder Interrogator

Figure 4 – Sample Front Panel of a Redesigned AI1422 Transponder Interrogator
Antenna Interface

Caution:
Connect Chassis Ground to system ground before attaching antenna!

Attach the antenna cable directly to the antenna interface on the front panel of the AI1422 Half-Frame Interrogator. 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 interrogator functions in real-time operating mode. In real-time mode, tag IDs are read and passed on to the host processor. Although hardware handshaking is wired on this interface, the algorithm is not implemented in the interrogator; therefore, hardware handshaking should not be enabled or implemented in the host controller, otherwise all messages will be inhibited from the host.

Figure 5 illustrates the RS–232, DB25 plug connector pin-outs.

![RS-232, DB25 Interface Connector Pin-outs](image)

Aux RS–232 Interface

The auxiliary RS–232 interface is used as a secondary interface for monitoring messages from the interrogator. The auxiliary RS–232 interface is a standard DB25 plug connector. This port is not wired to receive data and cannot accept commands. It is not necessary to use hardware handshaking on the auxiliary port.
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 6 shows the pin-outs on the customer I/O interface connector.

![Customer I/O Interface Pin-outs](image)

The customer I/O interface connector contains the interface for the Tag Lock light-emitting diode (LED), main power LED, RF power LED, the sense input, and IF channels A and B.

**Tag Lock Output**

The Tag Lock output indicates presence of a tag. The Tag Lock output goes active high when a valid tag is in the RF field of the antenna. This output may be connected to an LED, piezo buzzer, or oscilloscope for monitoring purposes.

The Tag Lock output is a +5 VDC output, with a 300-Ohm series resistor. This output is generated from an internal “handshake” signal that goes active whenever the FPGA decoder detects 20/40 kHz F2F encoding with a valid frame marker. The output Tag Lock signal is stretched to 14 milliseconds. When continuous valid data is detected, the Tag Lock signal will stay on continuously.

**Power Indicator**

The Power Indicator output goes active when power is supplied to the interrogator and the on/off switch is on. This output is driven to +5 VDC through a 300-Ohm resistor. This output can be connected to an LED to indicate power is on.
RF On Indicator

The RF On Indicator output goes active when RF output is active. The RF On Indicator output is connected to +5 VDC through a 300-Ohm resistor. This output can be connected to an LED to indicate RF is being transmitted.

Sense Input

The Sense Input causes the RF to activate when tied to signal ground and is connected to +12 VDC through a 1k ohm resistor.

Channels A and B

The interrogator intermediate frequency (IF) channel A and B signals represent two of the three channels generated by the Interrogator. These channels can be used in conjunction with an oscilloscope and two differential probes to measure tag signal fidelity.

Power Connection

The power connector on the front panel of the interrogator is a panel mount circular connector of type Cannon CA 3100 E16-10P-F80-T12.
Chapter 3 – System Test Procedures

This chapter describes the testing procedures for verification of basic operation, measuring RF power, system noise, and monitoring the system during normal operation.

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 interrogator
- Digital multimeter
- RF power meter or spectrum analyzer
- 20 dB attenuator
- 100 MHz oscilloscope, two differential probes
- Antenna, cable, and connectors

Testing Basic Operation

To test the system operation, configure the interrogator 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 interrogator.
2. Configure a terminal emulator (a PC using communications software) to 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 interrogator.
4. Switch off the ON/OFF switch located on the front panel of the interrogator.
5. Connect a power source to pins A (+) and B (−) on the DC power input front panel connector (Figure 7).
6. Switch on the ON/OFF switch located on the front panel of the interrogator.
7. Type the command `CC` (CC must be entered in upper case). No CR/LF are required.

*Note: For information on entering command codes, refer to “Commands” on page 28.*

8. Type `!22` and press Enter. The time and date will be returned.
9. If the time and date are not received, check communications connections, cycle power, and repeat.
10. 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 sense input (factory default)
    !41         Transmit all Tag ID Codes
    ```

    *NOTE: !41 command can only be used in Diagnostic Mode. Once Diagnostics Mode is exited, the reader will return to the default setting of sending the most recent tag read once.*

The interrogator will echo the command and respond with “!Done” for each properly executed command. The interrogator will respond with “!Error” for any invalid commands sent. No echo or response is sent for the command to enter Diagnostics Mode (````CC````).

### Measuring RF Power

To measure the RF power:

1. Set the ON/OFF switch located on the front panel of the interrogator to off.
2. Connect an RF power meter of known accuracy to the antenna interface on the front panel of the interrogator (Figure 8). Power measured at the antenna connector should be 28.5 dBm minimum.
Caution

**Most RF power meters or spectrum analyzers have input power restrictions, and the RF power output from the interrogator can severely damage the RF meter or spectrum analyzer if applied directly. Use an external attenuators of known value and adjust the RF power measurement by this amount.**

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 interrogator to on.

5. Repeat steps 6 through 8 under the section “Testing Basic Operation” on page 22 to configure the unit to operating conditions. The RF power measurement should read greater than 28.5 dBm.

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

   - $10\times\log(645)$ +28.1 dBm
   - Test cable loss 0.9 dB
   - Total +29.0 dBm

**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 per the parameters listed in Table 4.
Table 4 – System Noise Test Parameters

<table>
<thead>
<tr>
<th>Channel</th>
<th>Pins</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9 (A +) and 10 (A -)</td>
</tr>
<tr>
<td>B</td>
<td>11 (B +) and 12 (B -)</td>
</tr>
</tbody>
</table>

Figure 9, Figure 10, and Figure 11 depict waveforms generated at selected channels, as shown by an oscilloscope.

Figure 9 illustrates the desired waveform generated during normal operation with a valid tag in the interrogator field.

Figure 9 – Typical Waveform with a Tag in the Interrogator Field

Figure 10 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 10 – Typical Quiescent Noise Waveform

Figure 11 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 11 – Typical Beat Frequency Interference Waveform

Reading the Tag

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

1. Switch the ON/OFF switch located on the front panel of the interrogator to off.
2. Using your own cable, connect the laptop PC to the interrogator at the main RS–232 interface.
3. Connect the antenna to the antenna interface on the front panel of the interrogator.
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. These pins are located on the customer I/O interface on the front panel of the interrogator.

5. Set the ON/OFF switch located on the front panel of the interrogator to on.

6. Connect a jumper between pins 14 (ground) and 15 (sense input) on the customer I/O interface to cause the RF to activate. Refer to “Figure 6 – Customer I/O Interface Pinouts” on page 19.

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 back plate within 2 to 3 feet (0.6 to 0.9 m) of the antenna. No other tag can be in this area during this test.

9. Verify that the lock LED is illuminated and 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 interrogator 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 in Diagnostic Mode.

10. Remove the tag from the antenna field. The PC should stop reading the tag data.

11. Disable the sense input by disconnecting the jumper.

12. Set the power on/off switch located on the front panel of the interrogator 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.
Chapter 4
Commands
Chapter 4 – Commands

This chapter describes the data mode and diagnostic mode commands that allow a host computer to control the functions of the AI1422 Half-Frame Interrogator.

Table 5 – Data Mode Commands

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status Request</td>
<td>Causes the interrogator to respond with a message containing information indicating the rolling transponder seen count and the count of host error messages.</td>
<td>~~~@@</td>
</tr>
<tr>
<td>Retransmit Request</td>
<td>Requests the interrogator to retransmit the last tag ID read. (BB must be entered in upper case).</td>
<td>~~~BB</td>
</tr>
<tr>
<td>Enter Diagnostic Mode</td>
<td>Disables reading and reporting of tags and allows the interrogator to accept the diagnostic commands (CC must be entered in upper case).</td>
<td>~~~CC</td>
</tr>
</tbody>
</table>

Note: There is no carriage return or line feed required for any of these messages.

Data Mode

The transponder identification (ID) can be 3 or 10 bytes, which corresponds to 2400 or 9600 baud, respectively. These bytes are encoded in 6-bits ASCII. Refer to “Appendix A” on page 44 of this user guide. The interrogator sends these Transponder ID characters in 8-bit ASCII encoding.

All commands should be sent with a 1 millisecond inter-character delay and 1 second inter-message delay, minimum for the interrogator to properly interpret the message.

Asynchronous Interrogator Data Message

The interrogator sends the transponder ID in 8-bit ASCII via RS-232 through the DB-25 connectors on the front panel. The message format is as follows:

<7EH><7EH><01H><transponder count><transponder ID><CRC>

The interrogator transmits the most significant bit first. The CRC is calculated, starting with the most significant byte.

Table 6 presents the field descriptions.
Table 6 – Asynchronous Interrogator Tag Data Message Fields

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Hex</th>
<th>ASCII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of Message</td>
<td>These two bytes, along with the Message type byte, designates the start of the data message.</td>
<td>7E7E</td>
<td>~~~</td>
</tr>
<tr>
<td>Message Type</td>
<td>An 01H indicates that this message is a tag data message.</td>
<td>01</td>
<td>SOH</td>
</tr>
<tr>
<td>Transponder Seen Count</td>
<td>After power-up, this 8-bit count begins with 01 and is updated each time a tag with a unique ID moves out of the RF field, 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.</td>
<td>00 - FF</td>
<td>N/A</td>
</tr>
<tr>
<td>Transponder ID</td>
<td>The data that is programmed into the transponder. The data within the transponder is 6-bit ASCII but the interrogator translates this data into standard 8-bit ASCII.</td>
<td>-</td>
<td>ID</td>
</tr>
<tr>
<td>Cyclical Redundancy Check</td>
<td>An 8-bit cyclical redundancy check (CRC). Includes the Start of Header, the Seen Count and the Transponder ID. See Appendix D for a description of the CRC algorithm. There is no carriage return or line feed for this message.</td>
<td>00 - FF</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Status Request**

*Note: The Status Request shall only be used when the train is stationary. Sending this command simultaneous to tags being read can create a condition whereby the interrogator will no longer report tags until power cycled.*

All commands should be sent with a 1 millisecond intercharacter delay, minimum to allow the interrogator to properly interpret the message.

The Status Request command causes the interrogator to respond with a message containing information indicating the transponder seen count and host error messages.

The request command format is as follows:

<7EH><7EH><40H><CRC>
### Table 7 – Status Request Message Fields

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Hex</th>
<th>ASCII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of Message</td>
<td>These two bytes designates the start of the data message.</td>
<td>7E7E</td>
<td>~~~</td>
</tr>
<tr>
<td>Message Type</td>
<td>Sending a 40H indicates that this message is a status request.</td>
<td>40</td>
<td>@</td>
</tr>
<tr>
<td>Cyclical Redundancy</td>
<td>The 8-bit cyclical redundancy check (CRC) includes the</td>
<td>40</td>
<td>@</td>
</tr>
<tr>
<td>Check</td>
<td>Start of Header, the Seen Count and the Transponder ID. See “Appendix D”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>for a description of the CRC algorithm. This is a fixed value of 40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>hexadecimal, for this command.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>There is no carriage return or line feed for this message.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The response is:

<7EH><7EH><02H><Transponder count><host computer messages-bad CRC><incomplete host message> <Reserved><Reserved><Reserved><CRC>

### Table 8 – Status Response Message Fields

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Hex</th>
<th>ASCII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of Message</td>
<td>These two bytes, along with the Message Type byte, designates the start of the data message.</td>
<td>7E7E</td>
<td>~~~</td>
</tr>
<tr>
<td>Message Type</td>
<td>An 02H indicates that this message is a status response.</td>
<td>02</td>
<td>STX</td>
</tr>
<tr>
<td>Transponder Seen Count</td>
<td>The Transponder Seen Count is a single byte, hexadecimal field. At power-up, the interrogator initializes this Seen Count byte to 00. This value is incremented each time a tag with a unique ID moves out of the RF field, 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.</td>
<td>00 - FF</td>
<td>N/A</td>
</tr>
<tr>
<td>Number of Messages</td>
<td>At power-up, the interrogator initializes this byte with 00. It is incremented each time a message with a bad CRC is received from the Host.</td>
<td>00 - FF</td>
<td>N/A</td>
</tr>
<tr>
<td>Number of Messages</td>
<td>At power-up, the interrogator initializes this byte with 00. It is incremented each time an incomplete message is received from the Host.</td>
<td>00 - FF</td>
<td>N/A</td>
</tr>
<tr>
<td>Reserved</td>
<td>Reserved</td>
<td>0</td>
<td>NUL</td>
</tr>
<tr>
<td>Reserved</td>
<td>Reserved</td>
<td>0</td>
<td>NUL</td>
</tr>
<tr>
<td>Reserved</td>
<td>Reserved</td>
<td>0</td>
<td>NUL</td>
</tr>
<tr>
<td>Cyclical Redundancy</td>
<td>This field is a single byte (8-bits) cyclical redundancy check (CRC). Includes the Start of Header, the Seen Count and the Transponder ID. Refer to “Appendix D” for a description of the CRC algorithm. There is no carriage return or line feed for this message.</td>
<td>00 - FF</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Retransmit Request

*Note: The Retransmit Request shall only be used when the train is stationary. Sending this command simultaneous to tags being read can create a condition whereby the interrogator will no longer report tags until power cycled.*

All commands should be sent with a 1 millisecond intercharacter delay, minimum for the interrogator to properly interpret the message.

The Retransmit Request Command tells the transponder to retransmit the last tag ID. (BB must be entered in upper case).

The request command format is as follows:

<7EH><7EH><42H><CRC>

**Table 9 – Retransmit Request Message Fields**

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Hex</th>
<th>ASCII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of Message</td>
<td>These two bytes, along with the Message Type byte, designates the start of the data message.</td>
<td>7E7E</td>
<td>~~~</td>
</tr>
<tr>
<td>Message Type</td>
<td>Sending a 42H indicates that this message is a retransmit request.</td>
<td>42</td>
<td>B</td>
</tr>
<tr>
<td>Cyclical Redundancy Check</td>
<td>An 8-bit cyclical redundancy check (CRC) includes the Start of Header, the Seen Count and the Transponder ID. Refer to “Appendix D” for a description of the CRC algorithm. This is a fixed value of 42 hexadecimal, for this command. There is no carriage return or line feed for this message.</td>
<td>42</td>
<td>B</td>
</tr>
</tbody>
</table>

The response is

<7EH><7EH><01H><transponder count><transponder ID><CRC>
Table 10 – Retransmit Response Message Fields

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Hex</th>
<th>ASCII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of Message</td>
<td>These two bytes, along with the Message Type byte, designates the start of the data message.</td>
<td>7E7E</td>
<td>~~</td>
</tr>
<tr>
<td>Message Type</td>
<td>An 01H indicates that this message is a tag data message.</td>
<td>01</td>
<td>SOH</td>
</tr>
<tr>
<td>Transponder Seen Count</td>
<td>After power-up, this 8-bit count begins with 01 and is updated each time a tag with a unique ID moves out of the RF field, 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.</td>
<td>00 - FF</td>
<td>N/A</td>
</tr>
<tr>
<td>Transponder ID</td>
<td>The data that is programmed into the transponder. The data within the transponder is 6-bit ASCII but the interrogator translates this data into standard 8-bit ASCII.</td>
<td>-</td>
<td>ID</td>
</tr>
<tr>
<td>Cyclical Redundancy Check</td>
<td>An 8-bit cyclical redundancy check (CRC). Includes the Start of Header, the Seen Count and the Transponder ID. Refer to for a description of the CRC algorithm. There is no carriage return or line feed for this message.</td>
<td>00 - FF</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Diagnostic Mode

Enter Diagnostic Mode Command

~~CC

All commands should be sent with a 1 millisecond intercharacter delay, minimum for the interrogator to properly interpret the message.

Entering the diagnostic mode command disables reading and reporting of tags. This allows the interrogator to accept the diagnostic commands (CC must be entered in upper case).

The response is

No response is returned

Diagnostic commands are used to verify proper interrogator operation.

Diagnostic Mode Command Syntax

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 interrogator 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.

**Diagnostic Mode Commands**

The following commands are used for diagnostics of the interrogator.

**Type 1 Commands:**

**Baud Rate Select**

!100x

Command !100x selects the baud rate, where x = 1 to 6:

1 = 300 baud
2 = 1200 baud
3 = 2400 baud (factory setting depending on model)
4 = 4800 baud
5 = 9600 baud (factory setting depending on model)
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.*

*Note: Baud Rate settings are not stored in non-volatile memory and will return to factory settings after a power cycle.*

**Type 2 Commands:**

**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)
ss = 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.

Type 4 Commands:
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.
**Type 5 Commands:**

**Report Firmware Version Number**

Command \!505 requests a report on the interrogator’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 interrogator)*

- **AI1422 firmware version 1.00 Copyright 1999 Intermec Amtech**
  *(This response corresponds to the 10-character/3-handshake version of the AI1422 interrogator)*

- **Model AI1403 Ver 1.00**
  *(This response corresponds to the 3-character/3-handshake version of the AI1422 interrogator)*

**Transmit Number of Handshakes**

Command \!521 transmits number of handshakes to the host.

The response is

\!HDSH \( NN \) where \( NN \) is a rolling hexadecimal value (00 – FF) indicating the number of tag reads.

**Type 6 Commands:**

**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 Sense Input**

\!642

Command \!642 switches RF power on by sense input.

The response is

\!Done or \!Error

*Note: This command is for diagnostic purposes only.*
Manufacturing Diagnostic Menu

!66

Command !66 is to be used by manufacturing. Not for customer use.

Manufacturing Diagnostic RAM Check

!661

Command !661 is to be used by manufacturing. Not for customer use.

Exit Diagnostic Command Mode

!662

Command !662 Exits Diagnostic Mode. This allows the use of the following commands:

~~@@ for Status ("Status Request" on page 30.)

~~BB for Retransmission of transponder ID ("Retransmit Request" on page 32).

~~CC for entering Diagnostic Mode ("Diagnostic Mode Commands" on page 34).

The response is

!662

Note: Type 4 and Type 6 commands only change settings while in diagnostic mode. Upon exiting diagnostic mode, default operation will resume in data mode.
Chapter 5

Troubleshooting and Maintenance
Chapter 5 – Troubleshooting and Maintenance

This section lists routine diagnostic procedures for troubleshooting an improperly working interrogator and maintenance procedures to keep the AI1422 Half-Frame Interrogator 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 interrogator
- Digital multimeter
- RF power meter
- 100 MHz oscilloscope
- Antenna and cable
- Phillips head screwdriver

Troubleshooting

Failure Modes

This section describes the common failure modes of the interrogator.

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  enter 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 interrogator is communicating. If the interrogator is not communicating, then perform the following checks.

- Ensure the Interrogator has adequate power.
- Ensure the power switch is turn on.
- Is the main power switch light-emitting diode (LED) lit? If not, supply a power voltage to the power connector and turn on power switch.
- Ensure the front panel fuse is not blown. If so, replace it with properly rated Slo-Blo fuse (see front panel label for fuse rating).
• Check to see if the internal DC-DC voltage converter is functioning properly. Ensure the green “OK” LED on upper left corner of the front panel is illuminated. If not, it may be necessary to return the unit for repair.

• Ensure a null modem cable is being used.

• Ensure the correct baud rate is being used. The units have a default baud rate of either 9600 or 2400. Cycle power on the reader to reset the reader to one of these default settings and then enter ~CC and !505 CR/LF. The interrogator should respond with the firmware version.

**Unit Will Not Read Tags**

The suggestions listed here assume that the user has already verified proper serial communications. If RF Power LED is illuminated, the Ai1422 is querying for tags. If the Tag Lock LED is illuminated, the interrogator is retrieving tag data. If either LED is not illuminated, then check the following:

• Verify proper voltage to the unit is provided and the unit power is switched on.
• Verify that the antenna and antenna connection are good. This may be performed using a VSWR meter or measuring return loss.
• Verify a single, known valid tag is in the antenna field at a time.
• Verify the sense input remains activated.
• Verify at least two tags are being used with different data so that each one will be reported with the uniqueness filtering in the interrogator.

**Unit Will Not Retain Settings**

If the unit will not retain time and date over power cycle, the internal battery backup has failed and the unit must be returned for repair. Contact TransCore technical support.

**RF On Will Temporarily Override Sense Input**

Be aware, the RF On Command (!641) will temporarily override the RF On by sense input if sent while the interrogator is in Diagnostic Mode and the sense input is inactive (open). Upon exiting diagnostic mode, the Interrogator RF will remain on, even with the external sense input open; that is, until the external input is cycled, which will cause the interrogator to revert to RF on by sense input once again.
Maintenance Procedures

1. If your Interrogator has the optional rear panel installed, remove it by removing the four mounting screws (Figure 12).

![Figure 12 – Locations of Screws on Optional Rear Panel](image)

2. Connect a jumper between pins 14 (ground) and 15 (sense input) on the customer input/output (I/O) connector to turn on the RF power. Figure 6 on page 19 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 13 shows the location of pins 20 and 23.

4. Loosen retaining nut that secures R1 (Figure 13).

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 13 – 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 AI422 Half-Frame Interrogator.
### Appendix A

#### Character Conversion

Table 11 lists the ASCII 6-bit Codes.

<table>
<thead>
<tr>
<th>Character</th>
<th>ASCII 6-bit Code</th>
<th>Character</th>
<th>ASCII 6-bit Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>spc</td>
<td>000000 6</td>
<td>L</td>
<td>101100</td>
</tr>
<tr>
<td>!</td>
<td>000001 7</td>
<td>M</td>
<td>101101</td>
</tr>
<tr>
<td>&quot;</td>
<td>000010 8</td>
<td>N</td>
<td>101110</td>
</tr>
<tr>
<td>#</td>
<td>000011 9</td>
<td>O</td>
<td>101111</td>
</tr>
<tr>
<td>$</td>
<td>000100 ;</td>
<td>P</td>
<td>110000</td>
</tr>
<tr>
<td>%</td>
<td>000101 ;</td>
<td>Q</td>
<td>110001</td>
</tr>
<tr>
<td>&amp;</td>
<td>000110 &lt;</td>
<td>R</td>
<td>110010</td>
</tr>
<tr>
<td>'</td>
<td>000111 =</td>
<td>S</td>
<td>110011</td>
</tr>
<tr>
<td>(</td>
<td>001000 &gt;</td>
<td>T</td>
<td>110100</td>
</tr>
<tr>
<td>)</td>
<td>001001 ?</td>
<td>U</td>
<td>110101</td>
</tr>
<tr>
<td>*</td>
<td>001010 @</td>
<td>V</td>
<td>110110</td>
</tr>
<tr>
<td>+</td>
<td>001011 A</td>
<td>W</td>
<td>110111</td>
</tr>
<tr>
<td>,</td>
<td>001100 B</td>
<td>X</td>
<td>111000</td>
</tr>
<tr>
<td>-</td>
<td>001101 C</td>
<td>Y</td>
<td>111001</td>
</tr>
<tr>
<td>.</td>
<td>001110 D</td>
<td>Z</td>
<td>111010</td>
</tr>
<tr>
<td>/</td>
<td>001111 E</td>
<td>[</td>
<td>111011</td>
</tr>
<tr>
<td>0</td>
<td>010000 F</td>
<td>\</td>
<td>111100</td>
</tr>
<tr>
<td>1</td>
<td>010001 G</td>
<td>]</td>
<td>111101</td>
</tr>
<tr>
<td>2</td>
<td>010010 H</td>
<td>^</td>
<td>111110</td>
</tr>
<tr>
<td>3</td>
<td>010011 I</td>
<td>_</td>
<td>111111</td>
</tr>
<tr>
<td>4</td>
<td>010100 J</td>
<td></td>
<td>111111</td>
</tr>
<tr>
<td>5</td>
<td>010101 K</td>
<td></td>
<td>111111</td>
</tr>
</tbody>
</table>
Appendix B

Technical Specifications

Table 12 lists the specifications of the AI1422 Half-Frame Interrogator.

Table 12 – AI1422 Half-Frame Interrogator Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>19.0 x 5.25 x 9.0 in (48.3 x13.34 x 22.9 cm)</td>
</tr>
<tr>
<td>Weight</td>
<td>12.0 lb (5.4 kg)</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>+32°F to +158°F (+0°C to +70°C)</td>
</tr>
<tr>
<td>Power requirement</td>
<td>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)</td>
</tr>
<tr>
<td>Available frequency range</td>
<td>902–928 MHz</td>
</tr>
<tr>
<td>Approved frequency range for Federal Communications Commission and Industry Canada</td>
<td>902.25–903.75 MHz and 910.00–921.50 MHz</td>
</tr>
<tr>
<td>Receiver RF bandwidth</td>
<td>±3 dB point, approximately 1.2 MHz</td>
</tr>
<tr>
<td>Receiver sensitivity</td>
<td>-48 dBm</td>
</tr>
<tr>
<td>Transmitter frequency stability</td>
<td>±25.0 ppm over operating temperature range</td>
</tr>
<tr>
<td>Transmitter RF power</td>
<td>29.5 dBM ± 1 dB</td>
</tr>
<tr>
<td>Communications port</td>
<td>RS–232, 300 to 19,200 baud</td>
</tr>
<tr>
<td>Other features</td>
<td>Real-time calendar clock</td>
</tr>
<tr>
<td></td>
<td>Two grounding studs on front panel</td>
</tr>
</tbody>
</table>
# Appendix C

## Diagnostic Mode Command List

Table 13 lists the Diagnostic Mode Commands and their functions.

<table>
<thead>
<tr>
<th>Command</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>~CC</td>
<td>Enter Diagnostic Mode (CC must be upper case)</td>
</tr>
<tr>
<td>!100x</td>
<td>Baud rate select</td>
</tr>
<tr>
<td></td>
<td>1001 = 300 baud</td>
</tr>
<tr>
<td></td>
<td>1002 = 1200 baud</td>
</tr>
<tr>
<td></td>
<td>1003 = 2400 baud</td>
</tr>
<tr>
<td></td>
<td>1004 = 4800 baud</td>
</tr>
<tr>
<td></td>
<td>1005 = 9600 baud</td>
</tr>
<tr>
<td></td>
<td>1006 = 19200 baud</td>
</tr>
<tr>
<td>!20hh:mm:ss</td>
<td>Set the time in the real-time clock</td>
</tr>
<tr>
<td>!21MM/DD/YY</td>
<td>Set the date in the real-time clock</td>
</tr>
<tr>
<td>!22</td>
<td>Display time and date</td>
</tr>
<tr>
<td>!40</td>
<td>Disable transmit all tag ID codes</td>
</tr>
<tr>
<td>!41</td>
<td>Transmit all tag ID codes</td>
</tr>
<tr>
<td>!505</td>
<td>Report firmware version number</td>
</tr>
<tr>
<td>!521</td>
<td>Report number of handshakes</td>
</tr>
<tr>
<td>!640</td>
<td>Disable RF*</td>
</tr>
<tr>
<td>!641</td>
<td>Enable RF*</td>
</tr>
<tr>
<td>!642</td>
<td>RF on by sense input</td>
</tr>
<tr>
<td>!66</td>
<td>Manufacturing Diagnostic Menu (Not for customer use)</td>
</tr>
<tr>
<td>!661</td>
<td>Manufacturing Diagnostic RAM Check (Not for customer use)</td>
</tr>
<tr>
<td>!662</td>
<td>Exit Diagnostic Mode</td>
</tr>
</tbody>
</table>

*Only applies while in diagnostic mode*
Appendix D

Cyclic Redundancy Check

The cyclic redundancy check (CRC) is calculated, starting with the most significant byte.

The algorithm for the CRC used in the Interrogator is detailed here.

```c
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--)+
    {
        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 newByte low bit

        carryOld = carryNew;        // put carryNew into carryOld
    }

    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