

MPI 6000 Multi-Protocol Reader System Guide

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WARNING TO USERS IN THE UNITED STATES

**FEDERAL COMMUNICATIONS COMMISSION (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 Federal Communications Commission (FCC) rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency (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 laws in effect, the users 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, Inc. 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)**

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

A license issued by the FCC is required to operate this RF identification device in the United States. Contact TransCore, Inc. for additional information concerning licensing requirements for specific devices.

**TransCore, Inc.
USA**

Health Limits

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

For equipment operating from 300 to 1500 MHz the FCC limits on radiation exposure are contained in CFR title 47 part 1.1310.

Note: Frequency (f) is expressed in MHz.

Exposure Classification	Power Density	Averaging Time
Occupational/Controlled Exposure	$f/300 \text{ mW/cm}^2$	6 minutes
General Public/Uncontrolled Exposure	$f/1500 \text{ mW/cm}^2$	30 minutes

At **902 MHz** (worst case frequency for MPI 6000 operating band) these levels are

Exposure Classification	Power Density	Averaging Time
Occupational/Controlled Exposure	3.0 mW/cm²	6 minutes
General Public/Uncontrolled Exposure	0.6 mW/cm²	30 minutes

RF Levels From TransCore Equipment

Power density is given in milliwatts per centimeter (mW/cm) and is calculated as

$$S = \frac{PG}{4\pi D^2}$$

where

P = antenna input power (mW)

G = antenna gain referenced to an isotropic radiator

D = distance from antenna (cm)

For TransCore's IT2200 AVI system at maximum levels of

P = 1 W or 1000 mW, maximum

G = 14dBi or 25.1; AA3152 Universal Toll Antenna

S = 0.60 mW/cm², General Public Exposure Limit

S = 3.0 mW/cm², Occupational/Controlled Limit

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For the **maximum power level** (2 watts) the minimum safe distance is

$$D = \sqrt{\frac{PG}{4\pi S}} = 2.68 \text{ ft (81.5 cm) for **General Public Exposure Limit**, and 1.2 ft (36.46 cm) for **Occupational/Controlled Limit**$$

For a **typical operating power level of 0.5W** (-6dB attenuation from maximum power) the minimum safe distance is

$$D = \sqrt{\frac{PG}{4\pi S}} = 1.339 \text{ ft (40.8 cm) for **General Public Exposure Limit**, and 0.6 ft (18.3 cm) for **Occupational/Controlled Limit**$$

Any distance beyond 2.68 ft (0.82 m) from the antenna is compliant. Because antennas typically are mounted at heights of 18 ft (5.5 m), the minimum compliance distance should be met and maintained. Typical exposure levels should be below FCC exposure limits.

For example, a 6 ft (1.8 m) tall person standing in the center of the main lobe of the antenna would experience maximum RF levels of 0.03 mW/cm², and typical levels of 0.0075mW/cm². Even for the more stringent General Public Exposure Limit, the maximum exposure is 1/40th of the compliance level, and the typical exposure level is 4 times lower than that. For locations not centered in the main lobe of the antenna, the drop off in antenna gain reduces the radiation exposure for that area. A person standing 6 ft (1.8 m) to the side of an antenna would experience an additional approximate 10dB drop in power density.

For these reasons, the MPI 6000 falls within FCC exposure limits.

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Before You Begin

PRELIMINARY

Before You Begin

This chapter provides an overview of the MPI 6000 Multi-Protocol Reader System Guide.

Purpose of the Guide

This *MPI 6000 Multi-Protocol System Guide* provides an overview of the reader systems as well as a list of the reader software commands and diagnostic and hardware interface information.

Intended Audience

The intended audience for this guide is those personnel responsible for operating the MPI 6000 Multi-Protocol Reader.

Guide Topics

The *MPI 6000 Multi-Protocol System Guide* presents the following information.

Chapter 1 - Before You Begin	In process
Chapter 2 - Theory of Operation	In process
Chapter 3 - System Components	In process
Chapter 4 - MPI 6000 System Operation	In process
Chapter 5 - Diagnostics Information	In process
Appendix A - Acronyms and Glossary	In process
Appendix B - Block Diagrams	In process
Appendix C - System Technical Specifications	In process
Appendix D - Hardware Interfaces	In process
Appendix E - Reader Defaults	In process
Index	In process

Related Documentation

See the following related document:

MPI 6000 Reader Quick Reference Guide (in process)

Typographical Conventions Used in this Manual

The following conventions are used in this manual. Not all of the conventions are used in this version.

Table 1-1 *Typographical Conventions*



Convention	Indication
	This procedure might cause harm to the equipment and/or the user.
	A caution sign indicates 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.
Screen Title	Title of a screen as it appears on screen.
Menu Item	Appears on a menu.
<i>Note</i>	Additional 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 bold.
Cancel button	Bold text identifies the labeling of items as they actually appear on the keyboard, on a button, as a menu item, and so forth.
Ctrl-Esc	A hyphen indicates actions you should perform simultaneously. For example, Ctrl-Esc means to press the Ctrl and Esc keys at the same time.
5 Return	A space indicates that you should press the specified keys in the sequence listed, not at the same time.
<i>before</i>	Text in italics indicates emphasis.
Customer > Find	Bold text followed by a > and more bold text indicates the order of command selections to reach a specific function.
click	Click means that you should press and release the left mouse button.
cursor	The cursor is the flashing vertical line that appears in a selected edit box.

Table 1-1 *Typographical Conventions (continued)*

pointer	The pointer is the arrow in the window that shows the movement of the mouse.
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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.

TransCore data and literature are available to assist with approval and licensing activities.

U.S. Licensing

MPI 6000 systems users in the U.S. must obtain a license from the Federal Communications Commission (FCC). 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, but the TransCore dealer should provide assistance and support as necessary to complete these forms.

An FCC license provides the user with the legal authorization to operate the MPI 6000 systems on the licensed frequencies at the site specified in the license. Only an authorized installer or service technician can set the frequency for MPI 6000 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 RF identification product be used in the licensed area after the MPI 6000 equipment is installed.

PRELIMINARY

Developing the Installation Site Plan

PRELIMINARY

Developing the Installation Site Plan

This chapter will provide guidelines for the following tasks:

Assessing the Site and Formulating a Frequency Plan

Site Layout and Traffic Flow

Electrical and Communications Requirements

MPI 6000 and Tag Model Interoperability

Reading of Mixed Population Tags

Antenna Selection

Antenna and Tag Alignment

Polarization

Site Preparation Checklist

Components Checklist

Task Checklist

PRELIMINARY

Installing and Configuring the MPI 6000

PRELIMINARY

Installing and Configuring the MPI 6000

This chapter provides instructions for installing and configuring the MPI 6000 system. It also describes the individual components of the MPI 6000 system.

Overview of the MPI 6000

TransCore's MPI 6000 is an integrated high-speed, multi-protocol 915-MHz radio frequency identification (RFID) reader system that includes an RF transceiver board and processor in a single assembly.

The MPI 6000 can be integrated into an onsite lane controller or a NEMA enclosure. The MPI 6000 transmits and receives signals through a single antenna.

The MPI 6000 is capable of supporting any of the following protocols in a given installation:

- American Trucking Association (ATA), full-frame and half-frame (read-only)
- California Title 21 (read-only)
- eGo®¹ (read-only)
- Inter-Agency Group (IAG) (read/write)
- Super eGo (SeGo)* (read/write)
- TransCore IT2200 (read/write)

Where multiple tag protocols are used in the same installation, the MPI 6000 is capable of supporting any two of the above protocols.

The MPI 6000 is also suitable for a wide variety of automatic vehicle identification transportation applications, including electronic tolling, open road tolling, electronic vehicle registration, parking, and rail applications.

The following sections describe the specifications for the external connections from the MPI 6000 housing.

Connecting the MPI 6000 for Operation

External Connectors

This section lists the MPI 6000 external connections. Figure 3-1 shows the MPI 6000 connector locations.

1.*eGo tags are fully compliant with ANSI INCITS 256:2001 and ISO 18000-6 standards. SeGo is a superset of the eGo protocol.

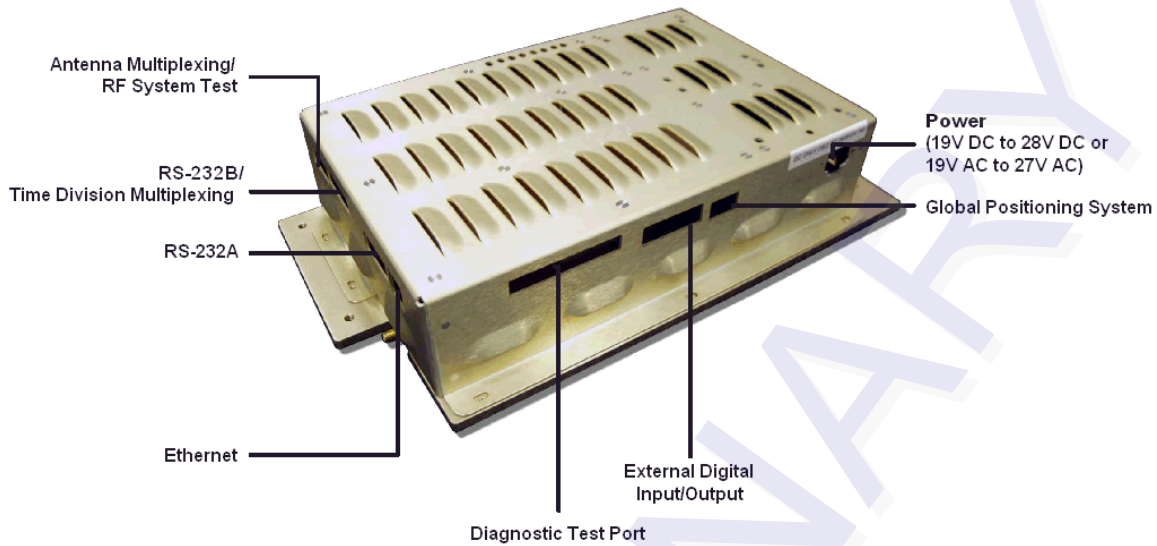


Figure 3-1 Connector Locations on MPI 6000 Enclosure

Power

The MPI 6000 requires 19V DC to 28V DC or 19V AC to 27V AC RMS voltage source. Table 3-1 lists the MPI 6000 external power connector specifications.

Table 3-1 MPI 6000 Power Connection Specifications

Connector Type	Two-Pin Terminal Block
Wire Gauge	12 – 30 AWG
Voltage	19V to 28V DC or 19V to 27V AC RMS Note If AC is used do not ground one end of the AC input, the AC supply must float.
Polarity	Either, power supply is polarity independent
Current	2 amps

RF Antenna Connector

The MPI 6000 Reader typically is connected to an AA3152 Universal Toll Antenna by a single low-loss RF cable. The antenna configuration is designed for overhead mounting on a gantry or sign structure. Figure 3-2 shows the antenna connector on the MPI 6000 enclosure.

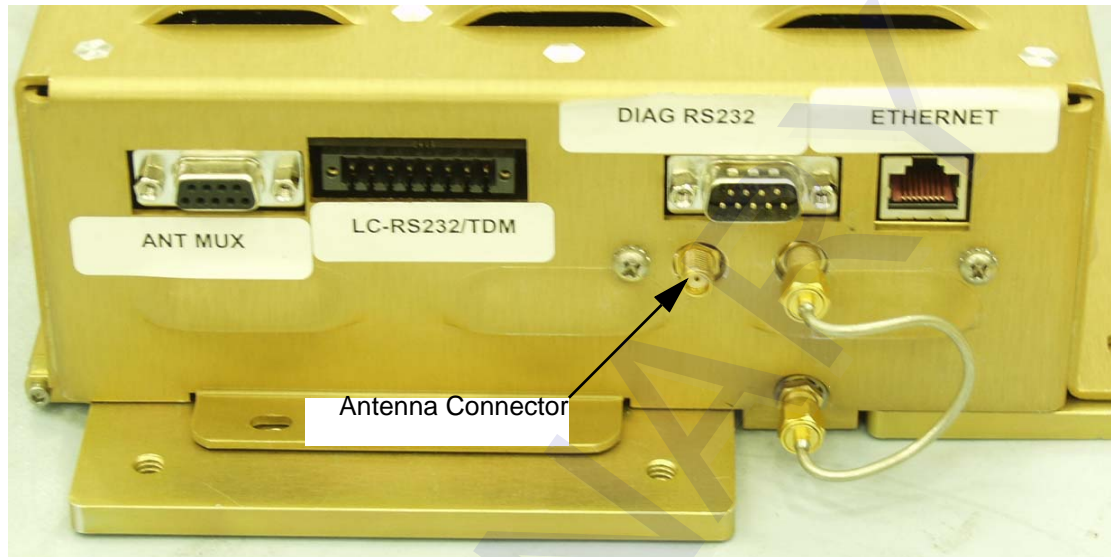


Figure 3-2 Antenna Connector Location

Table 3-2 lists the RF antenna connector parameters.

Table 3-2 RF Antenna Connector Specifications

Connector Type	SMA Female
Output Power	Up to 2 watts

RF Antenna Multiplexing/RF System Test Connector

This connector is used when a single MPI 6000 is used to operate multiple lanes.

Ethernet Connector

The MPI 6000 communicates with a host via an Ethernet communications protocol. This connection requires an RJ-45 connector. If you use a switch between the MPI 6000 and a host PC, you do not need a crossover cable. If you connect the MPI 6000 directly to a host PC then you need a crossover cable. If you set the host PC to *Dynamic*, TransCore recommends that you set the IP address to *Static*.

RS-232A Serial Communications Connector

The MPI 6000 communicates via a serial, RS-232, communications protocol (Table 3-3). The diagnostic RS-232 port can be used to display the operating system boot sequence.

Table 3-3 RS-232 Connector Specifications

Connector Type	9 pin D-sub male
Protocol	RS-232

Table 3-3 RS-232 Connector Specifications (continued)

Baud	9600
Bits	8
Parity	None
Stop Bits	1
Flow Control	None

Note: If you connect the MPI 6000 directly to a PC's serial port, you must use a null-modem.

By using the version command, you can display data about the configuration of the MPI 6000 including its Internet Protocol (IP) address. *(Mike, any more info here?)*

RS-232B/TDM Connector

Information to be provided.

RS-232 Diagnostic Test Port Connector

Information to be provided.

External Digital Input/Output Connector

Information to be provided.

Global Positioning System Connector

Information to be provided.

Installing and Using the MPI 6000 Host Software

This section provides instructions for installing the MPI 6000 host software on your host computer. You do not need the host to operate the MPI 6000, you can design an application programming interface using the MPI 6000 commands. Those configuration commands are explained in "Configuration Commands and Responses" on page 7-3 of this system guide.

If you choose to use TransCore's host software program, follow the instructions in the following sections.

Installing the Host Software

The MPI 6000 host program is used to communicate with the MPI 6000 and also display tag reads.

To install the MPI 6000 Host software

1. Load (*what media is used? CD? FTP site?*) the host software onto the host computer.

2. Run setup.exe and follow the commands to install the Host. The setup procedure installs an icon named **MPI 6000 Host** on your computer desktop.

The following sections tell you how to use the MPI 6000 Host software.

Connecting to the MPI 6000 Reader with the Host Software

1. Double-click on the **MPI 6000 Host** icon.
2. Select **UDP** on the main screen.
3. In the **UDP Command Link Config** field, enter the IP address of the reader.
Write the IP address near the Ethernet connector on the MPI 6000 enclosure for future reference.
4. Select **Establish Command Link**.
5. Select **E.xit**.

Configuring the MPI 6000 Reader Operating Frequency

1. Select the **Configuration** tab.
2. Select the **Transceiver Configuration** sub-tab.
3. Set the frequencies to desire values. Nominal values are 918.75 for downlink and 903 for uplink. Values must be between 902.25 and 903.75 or between 910 and 918.75 for the downlink. Values must be between 912.75 and 918.75 for the uplink.

Operating the MPI 6000 Reader

1. Select **Tags > FDOT**.
2. Enter hex data into the **IT2200 Write Data** and **SeGo Page Data** fields. Use 32 hex characters for IT2200 (Allegro) and 16 hex characters for SeGo. This is the data that is going to be written to the tag.
3. Select **Read** or **Write** in the SeGo Sequence Field. This sets the Read or Write parameters for both IT2200 and SeGo tags.
4. Press **Start** to begin tag processing.
5. Tag responses should appear in the IT2200 and SeGo fields.
6. To stop the display or the response count, select the check boxes.
7. Press **Stop** to end tag processing.
8. Press **Exit** to close the FDOT page.

MPI 6000 Readers have been preconfigured for most needed operations. Parameters such as attenuation, step-lock settings, and tag command sequences are set when the reader powers up.

PRELIMINARY

Lane Tuning Guidelines

PRELIMINARY

Lane Tuning Guidelines

This chapter explains the importance of lane tuning for optimum automatic vehicle identification (AVI) system performance and describes the MPI 6000 functions and features that can assist you in tuning an AVI lane.

Why You Need to Tune a Lane

Lane tuning is the procedure by which an installer can optimize the radio frequency (RF) characteristics and the signal timing of an AVI-equipped toll lane for the performance dictated by the lane's traffic requirements. Typically, consideration of these factors is necessary for each individual lane, although in some installations it may be possible to identify broader solutions, then apply these solutions to certain classes of lanes having similar characteristics, followed by additional fine tuning on an individual lane-by-lane basis. This process is necessitated by the radio link, which is subject to varying factors such as lane type, the geometry of fixed objects near the capture zone, interference from external sources, adjacent lane interference, natural non-homogeneity of RF field strength within the ideal capture zone, and varying tag environments. These factors may vary widely within an installation and from lane to lane within the same plaza. Furthermore, the type of technologies involved, either IT2200, American Trucking Association (ATA), eGo, eGo Plus, Title 21 or Inter-Agency Group (IAG), will play a significant role in tuning the lanes for operation. Knowing the appropriate factors and available tools is necessary for the set-up and troubleshooting of AVI lanes.

Required Equipment

You will need the following equipment and tools when you tune a lane:

TBD

Lane Tuning Parameters

Lane tuning parameters can be altered to effect required outcomes. This section lists the properties that can be used to tune a lane.

Traffic Requirements

The traffic requirements of lane tuning include the following characteristics:

- The duration of the tag transaction, also known as handshake

- Maximum traffic speed in the lane, which is used to determine the required length of the capture zone; also known as the footprint
- The type of lane, that is, express or mixed-use lane
- The presence of vehicle framing devices such as light curtains, which may dictate the desired location of the first read point
- The presence of alternate toll collection devices, such as coin machines in mixed-use lanes, which may dictate the desired first read point
- The width of the lane

Traffic requirements are further defined by two terms, tag transaction or handshake and capture zone or lane footprint.

Tag Transaction or Handshake

A handshake is defined as one complete transaction between a tag and the AVI equipment. The handshake is defined as a complete transaction because in many cases the transaction consists of more than a simple read. The transaction may be a read command followed by a general acknowledgment (GENACK), or a read command followed by a write command followed by a GENACK, or some other complex sequence of commands. Each part of the handshake requires time, and the transaction with the tag cannot be considered complete unless all the components have been completed. To this end, there will be a minimum time associated with the handshake. It may be as little as a few milliseconds, or as high as 30 milliseconds or more.

Capture Zone or Lane Footprint

The footprint is the length of the capture zone measured on the pavement, starting at the point of the first tag read and ending where tag reads stop, typically three or four feet past the receive antenna (Figure 4-1). This value is based on the actual measurements of the capture zones of at least five diversely different vehicles equipped with properly mounted tags. Ideally, RF margin plots taken at the time the footprint are measured on a foot-by-foot basis, but for the basic measurements discussed in this guide, all that is needed is the total footprint length from first read to last read.

To Be Provided.

Figure 4-1 Field Size, Shape, and Antenna Polarization Define the Reading Range

One concern for lane tuning is how large the footprint needs to be for acceptable system reliability. A rule of thumb frequently applied to this problem is that there should be time for a minimum of four complete transactions as the vehicle passes through the capture zone. Thus, the system that has the more complex transaction requires the larger footprint.

For example, if a toll agency requires an IT2200 tag read followed by a string of five GENACKs, this constitutes a complete transaction, and the total time would be four milliseconds for the IT2200 tag read plus four milliseconds for the five GENACKs for a total of eight milliseconds for the entire handshake. Four complete handshakes require 32 milliseconds. If the same agency has a maximum speed requirement of 60 mph through the lane, this translates to 88 feet per second, or 11.36 milliseconds/foot. The agency could use the system with a footprint that is 32 milliseconds in duration, which at 60 mph, translates to 11.36 milliseconds per foot or 2.82 feet. Any additional footprint increases the reliability of the system because the system provides more chances for the tag to interact with the reader.

1 read @ 4 milliseconds per read	= 4 milliseconds
5 GENACK @ 0.8 milliseconds per GENACK= <u>4 milliseconds</u>	
	= 8 milliseconds total, each full handshake

For another example, if the toll agency requires three pages to be read from the tag, followed by three pages of data to be written to the tag, followed by five GENACKS, the total transaction time is

3 reads @ 4 milliseconds each = 12 milliseconds
3 writes @ 4 milliseconds each = 12 milliseconds
5 GENACKs @ 0.8 milliseconds each = 4 milliseconds
= 28 milliseconds total, each full handshake

To complete 4 full handshakes (simply a rule of thumb), the vehicle would need to be in the footprint for 112 milliseconds. If the agency requires 100 mph operation, the vehicles travel one foot in 6.8 milliseconds. At this speed, the footprint would need to be 16.47 feet long to satisfy this requirement.

This footprint value can change depending on the use of time division multiplexing (TDM), which will increase the footprint requirements, or by using more sophisticated polling methods, which may reduce the footprint requirements. Furthermore, the times presented in this example for the individual components of the transaction can vary. For example, a password-protected read or write operation can take longer to complete than an ordinary read or write and can impact the overall statistical reliability of the transaction.

***Note:** Please consult with TransCore to assess the impact of the more sophisticated types of transactions.*

Given the uncertainties of any RF link due to reasons already discussed in this section, a short transaction of only a few milliseconds has a statistically better chance of succeeding than will a complex, longer 30-millisecond transaction. The tag is assumed to remain in the footprint for a minimum period of time relative to the maximum vehicle speed and the size of the footprint.

Once the length of the footprint has been determined, the presence of light curtains or detection loops may dictate the point at which the first tag read should occur. Also, manned lanes or mixed-use lanes typically require that the tag read occur at least a few feet in front of the toll collection point. The speed requirements may be reduced for these lanes and, hence, the footprint size. The point of the first read may be controlled by antenna placement, uptilt angle, and RF power, which are discussed later in this chapter. Likewise, if the lane is exceptionally wide or if there is a need for better coverage toward the lane sides, the antenna may be mounted higher or in line with other antennas. A lower gain antenna may be used to increase the side coverage.

RF Factors

The RF factors involved in tuning an AVI system may include the following parameters:

- The downlink and uplink transmitted RF power
- Range control adjustments that can be made to the receiver
- Antenna type
- Antenna mounting, that is, lane position (relative to payment point, angle, and height)

- The downlink and uplink source frequencies and interference from lanes sharing same or close frequencies
- The antenna-tag orientation

RF power is the most important RF factor in lane tuning. Thirty dBm translates to one-watt nominal power. Increasing the RF power will, in general, increase the footprint. There are other factors involved such as antenna angle and placement that may affect the footprint, but increasing RF power will generally increase the signal and increase both the footprint and the RF margins in the lane.

Because the RF power can create interference in adjacent or nearby lanes and degrade the performance of the adjacent lane, the RF power should be adjusted so that minimum power is used to achieve the desired results.

Downlink and Uplink Transmitted RF Power

Downlink signal is the signal transmitted from the reader to the tag, and uplink signal is the signal reflected back to the receiver from the tag. The impact of the downlink and uplink power on footprint and lane performance is heavily dependent on the protocol type(s) in use in the lane. Table x-x (to be provided) is a general guide to the influence of RF power on the footprint by protocol. Some of these factors are interrelated to such aspects as antenna angle, antenna placement, and tag placement, so use this information as a starting point and consider other aspects of lane tuning when operating on any given lane.

Both downlink and uplink power are adjustable by tag protocol. In other words, in multiple protocol systems, the RF power can be adjusted for each tag protocol in use, independent of the other tag protocol.

Range Control Adjustments

Adjusting the range control allows the user to adjust the footprint separate from any setting of the RF power. It is an adjustment on the sensitivity of the receiver and is done independently for each tag protocol. The units are in decibels and vary from 0 to 20dB, with the higher number giving the smaller footprint. Range control always exerts an effect on the footprint and performance separate from the tag protocol, but the degree of the effect may be dependent on RF power and antenna parameters as well. The most common use of range control is in multiple protocol situations, where the first read point of tags with two differing protocols must be made to coincide within a lane. In this situation, the power and antenna parameters are adjusted so that the weaker protocol tags are reading at the appointed position, then range control is used to adjust the first read point of the stronger protocol tags down to the same position as the other protocol. Range control can also be used in a single protocol situation to fine tune the first read position.

Frequency Considerations — Single Protocol

TBD

IT2200 or Title 21 Tag Protocol

TBD

This uplink frequency separation should repeat for additional lanes.

eGo Tag Protocol

TBD

ATA Tag Protocol

TBD

IAG Tag Protocol

TBD

Frequency Considerations — Multiple Protocols

TBD

Antenna-Tag Orientation

Antennas need to be oriented to match the tag orientation (Figure 4-2). Antennas also need to match the tag placement and vice versa. For example, if the tag is placed in the center of the windshield, the antennas should be placed overhead, centered, or nearly centered in the lane. If the tag is placed to the side of the windshield, the antennas should be placed overhead to the side matching the tag placement, or a side-mounted antenna should be used. There are some exceptions to this, and in the overall system planning, any variation from this rule should be discussed with TransCore at the earliest possible time to minimize additional costs for altering the lane design, especially after construction has started. Incorrect antenna placement may render the system's performance unacceptable and result in the eventual and expensive refitting of antenna and communication hardware. Figure 4-3 shows interior tag mounting locations, and Figure 4-4 shows exterior tag mounting locations.

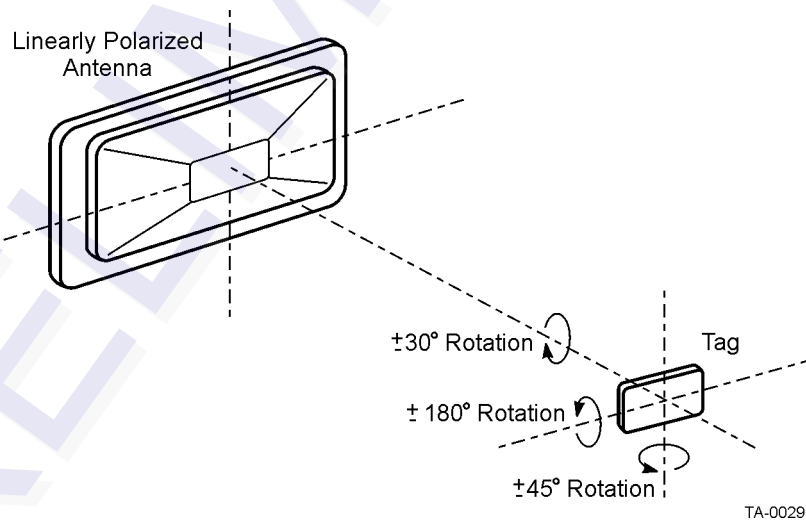


Figure 4-2 Tag Orientation with Linearly Polarized Antenna

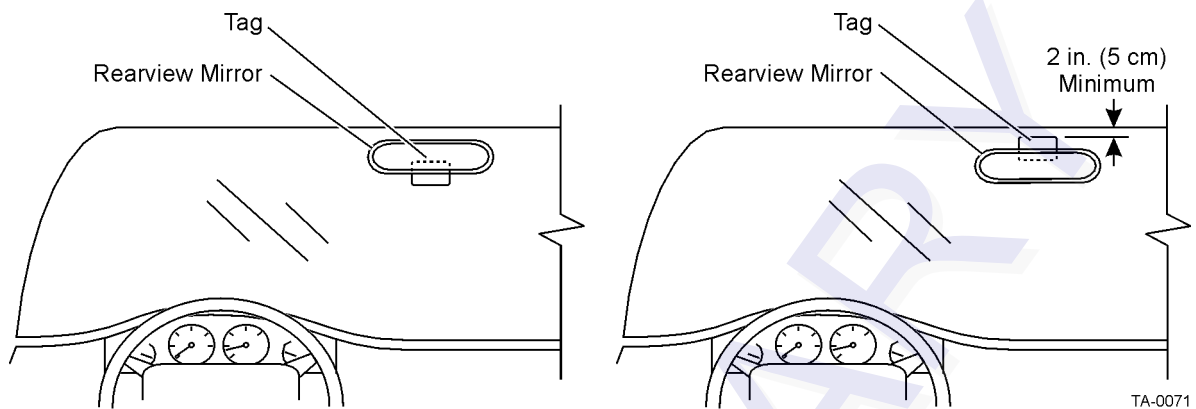


Figure 4-3 Upper Center Interior Windshield Tag Placement

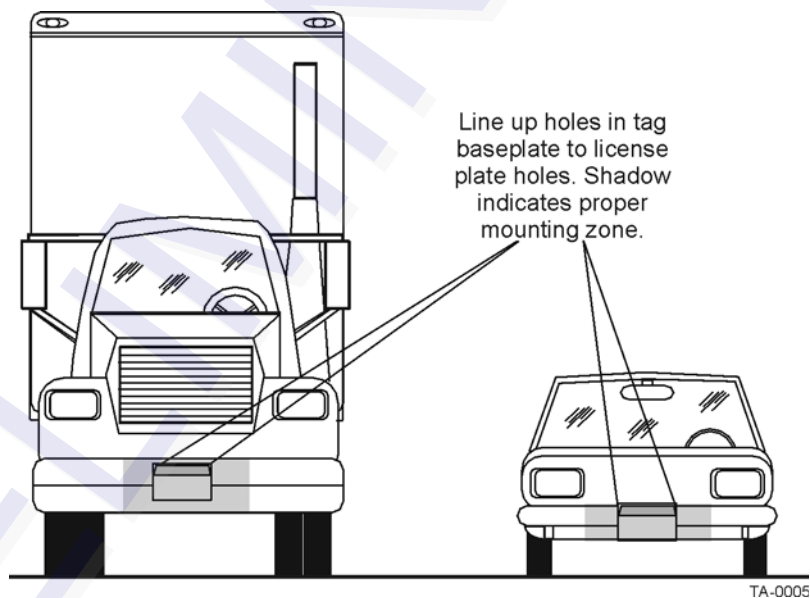


Figure 4-4 Correct Exterior Tag Placement

Antenna Uptilt Angle

Adjusting the antenna uptilt angle directly affects the footprint and the point of first tag read (Figure 4-5). As expected, a greater uptilt angle will move the point of first tag read farther from the antenna. However, at some uptilt angle, a point of diminishing return is reached where the RF power is too dispersed to activate the tag at the start of the footprint. Increasing the antenna angle beyond this point will not move the first read point farther out and may actually decrease the RF margin within the capture zone. Also, increasing the angle may produce an area near the start of the capture zone with spotty reads. The most commonly used range for antenna uptilt angles is from 10 to 25 degrees with the lower angles producing the sharpest, most clearly defined read zones. Setting the antenna uptilt angle below 10 degrees may cause problems in reading tags mounted on windshields that are nearly vertical and in read

ing license plate tags.

Note: TransCore does not recommend placing the antenna uptilt angles at less than five degrees.

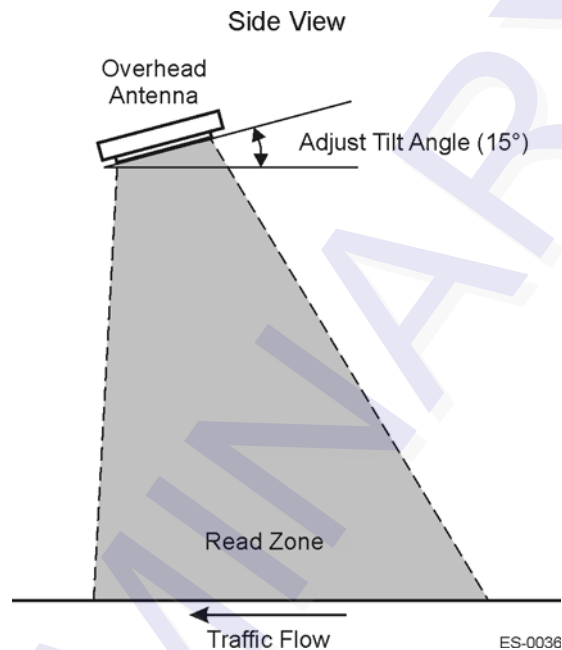


Figure 4-5 Overhead Antenna Tilt Angle

Antenna Positioning Within the Lane

In lanes where the antennas are mounted side by side, TransCore recommends that you install the transmit antenna toward the driver side of the traffic lane and the receive antenna toward the passenger side of the traffic lane. Antenna position in the lane also impacts lane performance.

Antenna mounting brackets should be designed so that you can adjust the antennas from front to back and from side to side. In lanes that have no vehicle framing, such as some express lanes, the front-to-back adjustment is not critical and can be minimized or eliminated. But, in these lanes it is still valid to have at least ± 2 feet (± 0.61 m) of side adjustment. Side adjustment may be critical in places where vehicles tend to travel to one side or another, such as in lanes that are wider than 12 feet (3.65 m). You can move the pair of antennas from side to side so that the centerline between the antenna pair is located over the area of the lane where the majority of traffic travels. RF reflectors, such as toll booths and Jersey barriers, may require you to make side adjustments to achieve adequate coverage to one side or the other.

The portion of the footprint with the highest RF margin has the highest probability of a successful tag transaction. This portion of the footprint is the area directly under the antenna and extending forward (upstream) a number of feet. If the length of the footprint is not an issue, such as the situation in some lower speed mixed-use lanes, but the point of first read is critical, it may be advisable to use a low antenna angle. Next, adjust the antenna position so that the first read occurs at the desired point. Adjust the antenna position instead of fixing the antenna position and adjusting the first read point by manipulating the antenna uptilt angle or the RF power. This adjustment may

enable you to operate the lane at a lower RF power, which is usually the preferred operational mode.

Signal Timing
TBD

PRELIMINARY

PRELIMINARY

PRELIMINARY

PRELIMINARY

Optimizing MPI 6000 Reader System Performance

PRELIMINARY

Optimizing MPI 6000 Reader System Performance

This chapter provides information to optimize the MPI 6000 performance and reduce cross-lane interference.

Cross-Lane Interference in RFID Systems

Radio frequency identification (RFID) systems are subject to various types of interference that can affect the level of communications between a tag and a reader system. A type of interference that can result from the operation of the reader system is called cross-lane interference.

What Is Cross-Lane Interference?

Cross-lane interference occurs when the RF generated in one toll lane interrupts the RFID operation in another lane that causes the affected lane to perform poorly. Before diagnosing cross-lane interference, it is necessary to understand what constitutes a satisfactorily performing lane.

Determining Acceptable Lane Performance

The criteria for optimal lane performance are usually set by the customer and can vary according to the site requirements. In testing, acceptable lane operation criteria typically are determined by the length of the RF footprint and the speed of the test vehicle. Usually, a test vehicle's speed is limited by the amount of the toll lane that can be used for starting and stopping distances. Usually, testing speed is limited to 20 miles per hour (mph) or 32 kilometers per hour (kph) or less.

An ideally performing toll lane will produce one handshake for every 4 milliseconds of transaction time. At 20 mph (32 kph), the vehicle uses 34 milliseconds to travel through 1.0 foot (0.3 m) of the footprint. If the footprint is 8 feet (2.4 m), this means that the vehicle will spend approximately 272 milliseconds in the footprint. Based on a vehicle speed of 20 mph (32 kph) and an 8-foot (2.4m) footprint, this yields an ideal maximum number of 68 handshakes. Nulls and voids within the RF footprint will lower this number, as will any other local sources of RF noise and stray reflections. A rule of thumb for lane performance is to have 40 to 60 handshakes within an 8-foot (2.4m) footprint with a test vehicle traveling at 20 mph (32 kph). A system that operates with less than 40 handshakes should be tested for cross-lane interference.

Identifying Cross-Lane Interference

Cross-lane interference is identified by an area in the RF read zone, or footprint, which has areas where a tag cannot be read. If a toll lane has been operating satisfactorily and then begins to show a degradation in system performance, that is, an increasing number of missed reads or a spotty read pattern, there is a probability that cross-lane interference is occurring.

Cross-lane interference can be caused by the following:

- A downlink antenna transmitting strong RF beyond its lane boundaries
- Reflection of RF from fixed objects (e.g., toll plazas with low, metal roofs)
- Reflection of RF from moving objects (e.g., a passing tractor-trailer in an adjacent lane)

A typical toll lane application encompasses more than a single lane. In some cases a toll plaza can have more than eight lanes with each lane having separate RF transmitting (downlink) and receiving (uplink) antennas. As shown in Figure 5-1, the RF transmitted within a lane is not bound by physical dividers such as lane barriers. With multiple-lane applications, transmissions out of a lane can create areas of possible cross-lane interference.

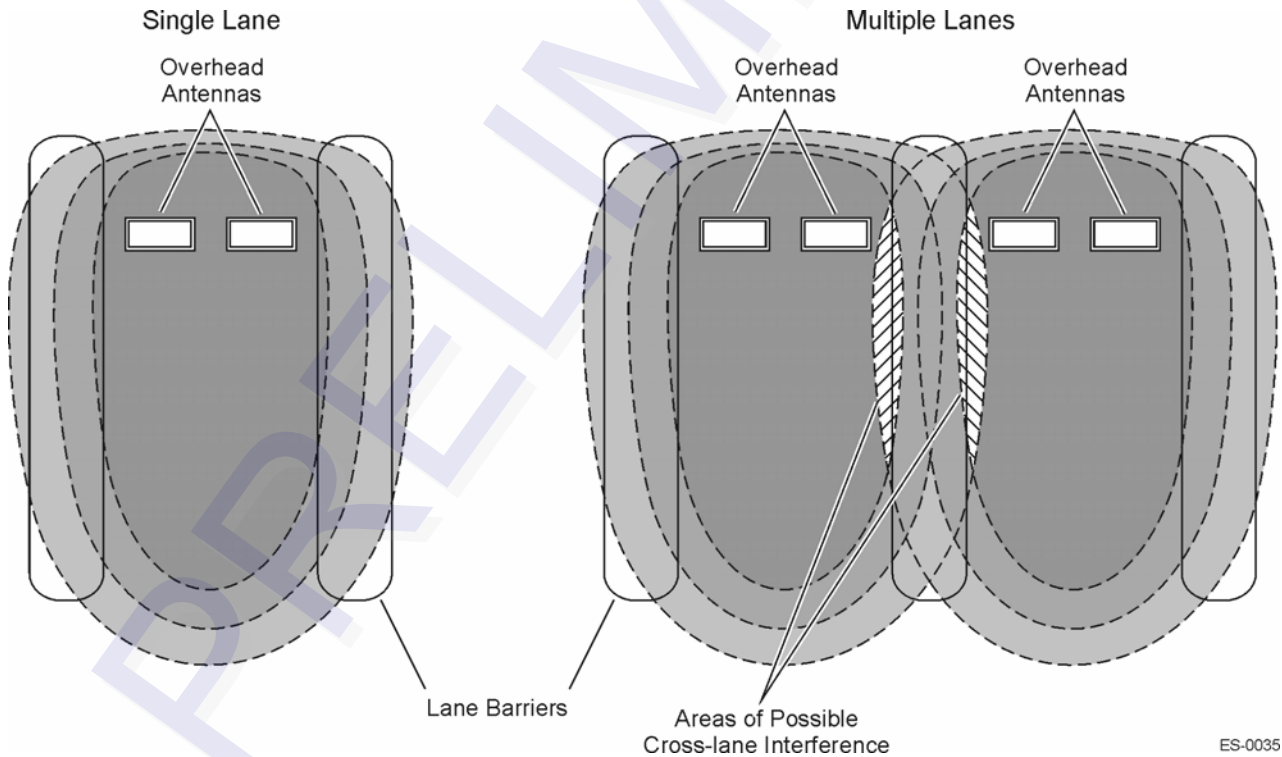


Figure 5-1 RF Footprint Extends Beyond Lane Boundaries

Diagnosing Cross-Lane Interference

To diagnose this type of interference, first set the RF power in all lanes to a moderate setting of 6 to 9 decibels (dB) for both downlink and uplink antennas. Next, tune a single lane. When tuning a lane be sure to use a tag and vehicle that have been used consistently at your site.

Once the lane has been tuned and you determine that it is working satisfactorily, perform lane tuning procedures in the adjacent lane. Continue for each lane in the toll plaza.

If each adjacent lane tuning causes the previously tuned lane to start performing poorly (i.e., spotty read zone or areas of no reads), cross-lane interference is indicated.

Remedying Cross-Lane Interference

Several methods exist to remedy cross-lane interference. These remedies are accomplished by software or hardware changes, or a combination of both. A remedy at one site may not be appropriate at another site, so iterative methods of correcting this interference are necessary.

Frequency Separation

Review the toll plaza frequency plan that was developed during the eGo 4110A Reader System installation phase. There are two frequencies for each reader: downlink and uplink. For the eGo 4110A Reader System, all readers share the same downlink frequency, which is generally set to 918.75 MHz. Uplink frequencies should alternate between 903.00 MHz and 910.00 MHz in adjacent lanes. For example, a four-lane plaza would have the frequencies shown in Table 5-1.

Table 5-1 Frequency Plan for Four-Lane Toll Plaza Using IT2200-series or Title 21 Tag Protocol

Lane	Downlink Frequency	Uplink Frequency
1	918.75 MHz	903.00 MHz
2	918.75 MHz	910.00 MHz
3	918.75 MHz	903.00 MHz
4	918.75 MHz	910.00 MHz

RF Power

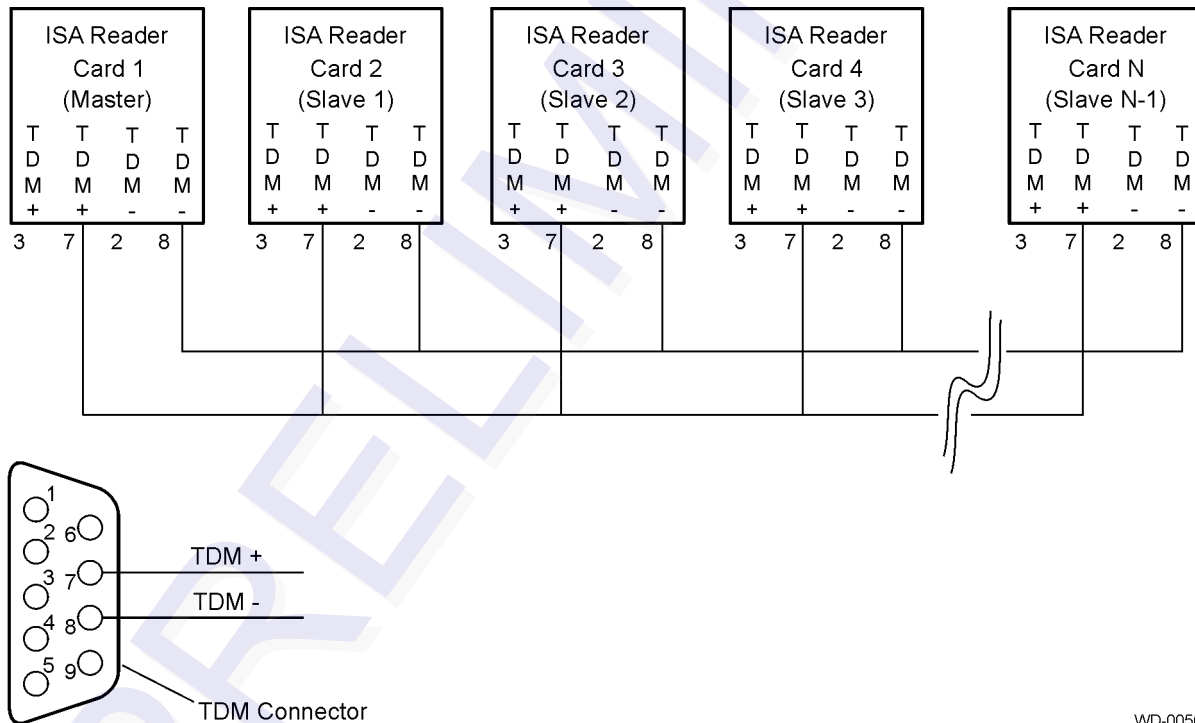
A good rule of thumb when configuring a toll plaza is to set the RF attenuation at a lower output and increase the RF power level as needed for optimal system operation. This practice may provide you with RF attenuation settings at which your reader system can operate with minimal adjustment for cross-lane interference.

Time-Division Multiplexing

In situations where cross-lane interference can occur in an installation, and frequency management is not sufficient to solve the problem, you may need to use time-division multiplexing (TDM). By using the TDM function in readers, individual readers operate only during interleaved time periods.

The TDM interconnect is provided via a differential RS-485 interface to a DB9 connector that is located on the reader card's expansion board connector in slot 2. This connection provides a synchronization interface between readers where RF interference between readers is reduced by multiplexing the RF reader transmission to independent time slots. Allowing each reader or group of readers to operate at an allotted time eliminates interference from readers in adjacent lanes.

Although you need to configure the readers to operate using TDM, the interface connection for TDM can be provided to all the readers in a plaza before or during installation by connecting a pair of wires to the DB9 TDM connector of each reader as shown in Figure 5-2. No other equipment is necessary for the interconnection circuit. You need to follow the polarity conventions as shown because this interface is polarity dependent.



WD-0056

Figure 5-2 TDM Configuration Example

TransCore recommends Belden 89182 or 8132 cable. Using these low-loss, low-capacitance twisted-pair cable, the maximum distance is 1000 feet (305 m). Cables with lower capacitance can be used to run the TDM cables for longer distances while maintaining signal integrity. This maximum distance may be slightly longer or shorter depending on the cable used.

Because the TDM signals are based on RS-485 signals, you can extend the length of the TDM bus by using RS-485 repeaters or by using fiber with converters. Either of these two modifications should be used only when absolutely necessary in situations where the TDM lengths need to exceed the 1000-foot (305-m) maximum distance. Table 5-2 shows the pin designations and descriptions for the TDM connector.

Table 5-2 TDM Connector

Pin	Name	In/Out	Description	Recommended Connection
1	N/C	N/A	No connection	N/C
2	N/C	N/A	No connection	N/C
3	N/C	N/A	No connection	N/C
4	N/C	N/A	No connection	N/C
5	N/C	N/A	No connection	N/C
6	N/C	N/A	No connection	N/C
7	TDM (+)	In/Out	TDM synchronization positive	Connect all red pin 7 wires together.
8	TDM (-)	In/Out	TDM synchronization negative	Connect all black pin 8 wires together.
9	N/C	N/A	No connection	N/C

To implement TDM, you must configure only one reader in the group as a master reader for the TDM function. This reader will have a slightly shorter synchronization period than the rest of the readers connected to it.

Note: The TDM synchronization period is set in 1.0-millisecond increments, whereas the TDM delay and TDM duration are set in 0.5-millisecond increments.

Figure 5-3 illustrates a typical plaza configuration using TDM. There are three time slots with three uplink frequencies. All the readers are configured with a downlink frequency of 916 MHz.

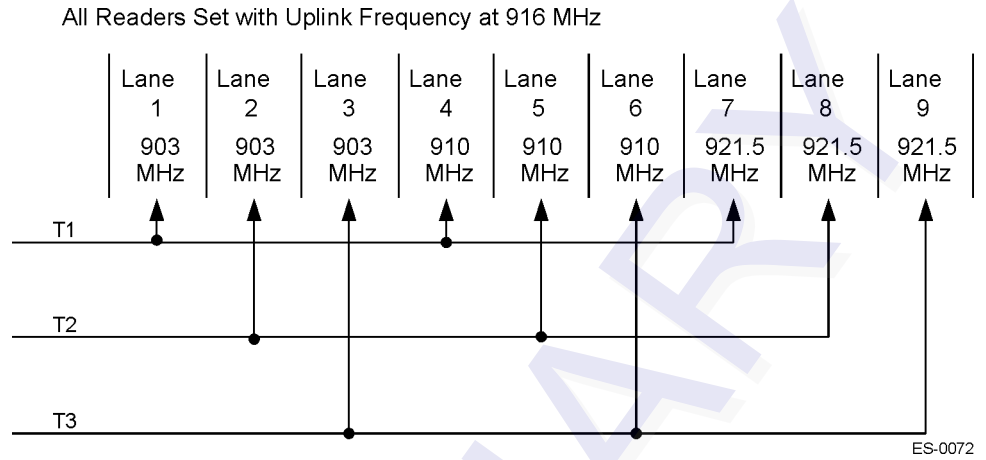


Figure 5-3 Typical Plaza Configuration Using TDM

The frequency settings and the 9-millisecond TDM time slots were determined based on a Title 21 tag transaction. For other installations, the frequencies and TDM duration need to be determined based on the type of transaction and expected vehicle speeds for that installation. Figure 5-4 shows a timing diagram for the readers in each of the time slots. Table 5-3 lists the settings for each reader in each time slot.

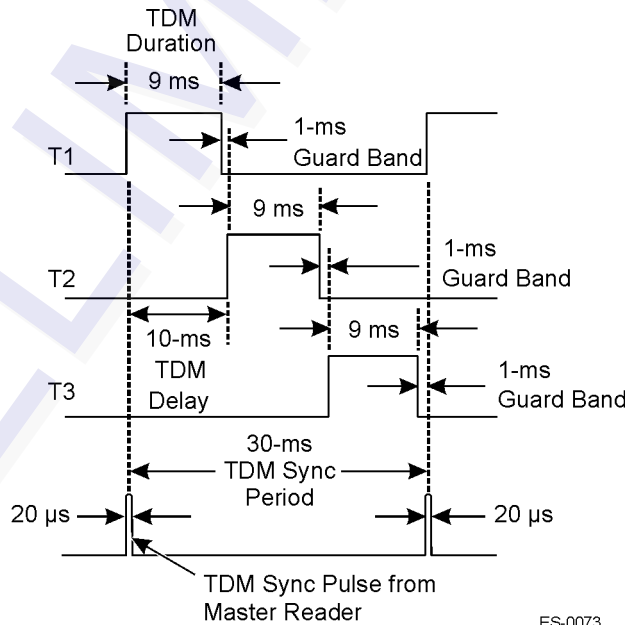


Figure 5-4 TDM Timing Diagram

Table 5-3 TDM Timing Settings

Time Slot	TDM Delay	TDM Duration	TDM Synchronization Period ^a
T1	0 ms (setting = 0)	9 ms (setting = 18)	31 ms (setting = 31)
T2	10 ms (setting = 20)	9 ms (setting = 18)	32 ms (setting = 32)
T3	20 ms (setting = 40)	9 ms (setting = 18)	33 ms (setting = 33)

a. Master reader TDM synchronization period equals 30 milliseconds.

Note: The TDM synchronization period is set in 1.0-millisecond increments, and the TDM delay and TDM duration are set in 0.5-millisecond increments.

The TDM example shown in Figure 5-4 and Table 5-3 was designed with three time slots; however, two time slots can be used instead depending on the number of frequency channels and the timing. Implementing TDM with three time slots reduces the time available for a transaction in a given lane by a factor of three. Similarly, implementing TDM with two time slots reduces the time available for a transaction in a given lane by a factor of two. Although it is possible to implement four or more time slots, it is unlikely that more than three time slots are necessary or beneficial.

TransCore recommends that a guard-band of 1 millisecond be used between each of the time slots to ensure that the readers in the previous time slot have sufficient time to settle before the readers in the next time slot become active. This procedure can be done by setting the TDM delay on each reader to account for a duration that is 1 millisecond longer than the actual duration and setting the TDM synchronization period to a value that accounts for a duration 1 millisecond longer than the actual duration.

All the readers designated as slave readers in the plaza on the same TDM bus are dependent on the synchronization signal from the master reader. In the event that the synchronization pulse from the master reader stops functioning, or the TDM signal from the master reader becomes disconnected from the rest of the readers in the plaza, a provision in the readers allows a slave reader to serve as a backup master reader and supply the synchronization pulse. Although this situation will cause the slave reader to send an error message to the lane controller, the slave reader will continue to function and provide the TDM synchronization pulse for the other operational readers on the remaining TDM bus.

Because the location in the plaza where the signal break may occur is unknown, TransCore recommends that provisions for a break anywhere in the line be considered. Although the TDM synchronization period settings for the slave readers could all be set at the same single value of 1 millisecond longer than the value used for the TDM synchronization period on the master reader, they should be set at unique values increasing at 1 millisecond for each reader, starting at a value 1 millisecond higher than that of the master reader. This setting ensures that only one reader will provide the synchronization pulse to a given group of readers in the plaza remaining on the

TDM bus in the event of either a TDM connection failure, or a failure of the TDM circuit in the master reader, which also reduces the number of readers that will generate TDM failure messages in any one of these failure scenarios.

Physical Remedies

By adjusting the angle or position of the downlink and uplink antennas, you may be able to minimize cross-lane interference.



Warning

Switch off RF power before working on antennas.

Adjusting the Antenna's Uptilt Angle

Lowering an antenna's uptilt angle between the antenna cover and the horizon generally reduces the interference (Figure 5-5).

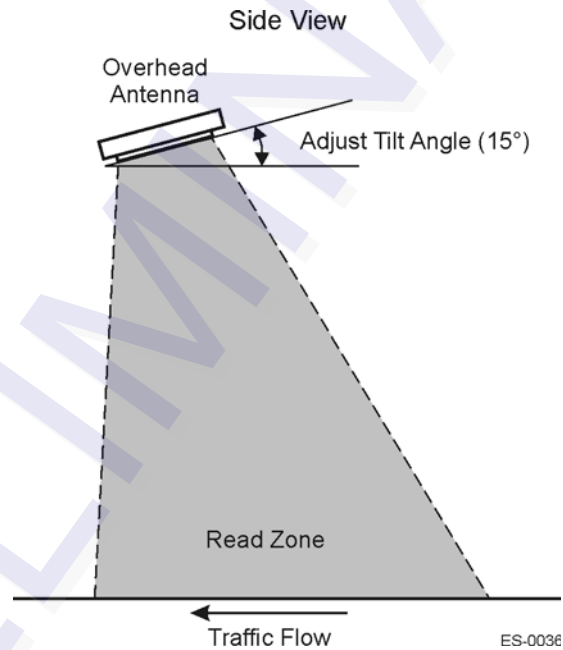


Figure 5-5 Antenna Tilt Angle Adjustment

Adjusting the Antenna Side Angle

In the eGo 4110A Reader System, you can adjust an antenna's side angle so that the RF transmits toward the center of the toll lane, placing the RF footprint into the lane. If the side angle is too small, the footprint can project into the lane nearest to the tilted antenna. If the side angle is too large and the RF footprint is projecting toward the other antenna, you can reduce the side angle so that the antenna's RF footprint is evenly placed within the correct lane boundaries. Figure 5-6 shows the downlink antenna being tilted toward the center of the lane.

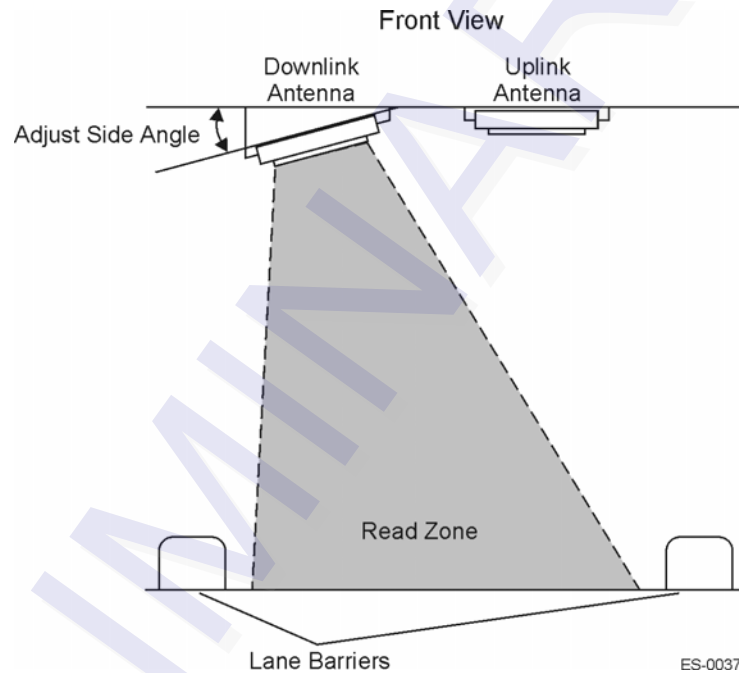


Figure 5-6 Downlink Antenna Side Angle Adjustment

Adjusting the Antenna Placement

Besides adjusting the antenna angles, you can also move the antenna farther back into its overhead location so that the read zone does not extend as far in front of the transaction area. By shortening the read zone, you may be able to reduce the required RF output power, which will result in reduced probability of cross-lane interference.

You can also move the antenna pair from side to side within the lane. This adjustment is used in lanes where the traffic travels closer to one side than another. For example, in manned toll lanes, traffic tends to drive closer to the left side of the lane. The centerline between the antennas can be shifted to the left to compensate for this tendency.

Other Site Modifications

In rare instances, applying radar-absorbing foam to fixed areas of the toll plaza (e.g., metal roof) may reduce the incidence of interference.

PRELIMINARY

General Software Information

PRELIMINARY

General Software Information

This chapter provides general software information about the design of MPI 6000 system application software, as well as information required for using reader system components in the design and integration of an automated toll, traffic management, or automatic vehicle identification (AVI) system.

General Software Information

All tag programmer commands are preceded by a start-of-message (<som>) ampersand character (&) followed by an end-of-message (<eom>) percent character (%). All data after the <eom> character is ignored until the next <som> is detected.

Any & character that occurs in the message between the <som> and <eom> is converted to the backslash and *at* character (\@) sequence. Any % character is converted to the \? character sequence. All \ characters are converted to the \\ sequence. All <som> and <eom> character conversions are performed after the cyclic redundancy check (CRC) has been performed on the transmit data and before the CRC is performed on the receive data.

Reader commands contain only the message information and are not preceded by the & and are not followed by the %.

Plan and Organize

Tags compatible with the eGo 4110A Reader System have sophisticated memory organization. TransCore encourages the user to become familiar with the use and organization of tag memory. Before starting a programming session, TransCore recommends that you plan and organize the development steps.

Communications Protocols

The MPI 6000 communicates with a host by Ethernet or serial communications protocols.

Ethernet

The MPI 6000 can communicate via an Ethernet communications protocol. This connection requires an RJ-45 connector for the Ethernet receptacle. The Ethernet connector is an RJ-45 jack and uses a 10-base T interface. If you use a switch between the MPI 6000 and the host personal computer (PC), no crossover cable is required. If the MPI 6000 is connected directly to the host PC then a crossover cable is required. If the

host PC is set to *Dynamic* TransCore recommends that you set the IP address to *Static*. Table 6-1 lists the connector pin assignments.

Table 6-1 Ethernet Connector

Pin	Signal	Description
1	TPTX+	Output Differential Transmit Data +
2	TPTX-	Output Differential Transmit Data -
3	TPRX+	Input Differential Receive Data +
4	NOT CONNECTED	N/A
5	NOT CONNECTED	N/A
6	TPRX-	Input Differential Receive Data -
7	NOT CONNECTED	N/A
8	NOT CONNECTED	N/A

Communications RS-232

The connector is an industry standard DB-9M plug. Table 6-2 lists this connector pin assignments.

Table 6-2 Communications RS-232 Connector Parameters

Pin	Signal	Description
1	RSD	Received line signal detect (not connected)
2	RXD	Receive Data
3	TXD	Transmit Data
4	DTR	Data Terminal Ready (not connected)
5	GND	Ground
6	DSR	Data Set Ready (not connected)
7	RTS	Request to Send
8	CTS	Clear to Send
9	RI	Ring indicator (not connected)

The RS-232B/Time-division multiplexing (TDM) connector is an 8-pin terminal block header. The TDM signals must be isolated. Table 6-3 lists this connector pin assignments.

Table 6-3 RS-232B/TDM Connector Parameters

Pin	Signal	Description
1	TXD	Transmit Data
2	RXD	Receive Data
3	DTR	Data Terminal Ready (not connected)
4	RTS	Request to Send
5	CTS	Clear to Send
6	GND	Ground
7	TDM +	TDM positive signal
8	TDM -	TDM negative signal

Diagnostic RS-232 Serial Communications

The MPI 6000 can communicate via a serial, RS-232, communications protocol (Table 6-4). The diagnostic RS-232 port can be used to display the operating system boot sequence.

Table 6-4 RS-232 Connector Specifications

Connector Type	9 pin D-sub male
Protocol	RS-232
Baud	9600
Bits	8
Parity	None
Stop Bits	1
Flow Control	None

If you connect the MPI 6000 directly to a host PC serial port, you must use a null-modem connector.

Diagnostic Commands (Mike?)

By using the version command, you can display data about the configuration of the MPI 6000 including its Internet protocol (IP) address.

The RS-232 diagnostic connector can be used to check the external input/output status. Table 6-5 lists this connector pin assignments.

Table 6-5 Diagnostic RS-232 Connector Parameters

Pin	Signal	Description
1	5V PWR	5V power supply for I/O board
2	GND	GND
3	I/O Signal 1	Input/output signal 1
4	I/O Signal 2	Input/output signal 2
5	I/O Signal 3	Input/output signal 3
6	I/O Signal 4	Input/output signal 4
7	Tag in Field 1	Contact Closure 1 for Tag in Field Signal
8	Tag in Field 2	Contact Closure 2 for Tag in Field Signal

Reader Command Protocol

The MPI 6000 implements command requests, data acknowledgements, command responses, asynchronous responses, software flow control, and unsolicited status messages as required for AVI system configuration and operation. The messages are defined in this section.

Command request messages are initiated and used by the host to request specific actions to be performed by the MPI 6000.

Data acknowledge messages are initiated and used by the MPI 6000 to signal the reception of command request messages received from the host. Additionally, data acknowledge messages are initiated and used by the host to signal the reception of command response, asynchronous response, software flow control and unsolicited status messages received from the MPI 6000.

Command response messages are initiated by the MPI 6000 in response to specific command request messages received from the host.

Asynchronous response messages are optionally initiated by the MPI 6000 in response to specific command request messages received from the host.

Software flow control messages are initiated and used by the MPI 60000 System to inform the host to start or stop sending command request messages. Additionally, software flow control messages are initiated and used by the host to inform the MPI 60000 System to start or stop sending messages.

Unsolicited status messages are initiated and used by the MPI 60000 System to inform the host about specific warning or error conditions in the MPI 60000 System.

The host sends command request messages to the MPI 6000. The MPI 6000 after receiving command request messages from the host sends data acknowledge messages, command response messages, asynchronous response messages and if required

software flow control messages to the host. The host on receiving command response messages, asynchronous response messages and software flow control messages from the MPI 6000 sends data acknowledge messages to the MPI 6000.

Additionally, the MPI 6000 sends unsolicited status messages to the host. The host on receiving unsolicited status messages from the MPI 6000 sends data acknowledge messages to the MPI 6000.

The MPI 6000 implements message sequence numbers and command sequence numbers in all of the message types (e.g. command request, data acknowledge, command response, asynchronous response, software flow control and unsolicited status). The host and the MPI 6000 must implement independent transmit and receive counters for both the message sequence numbers and the command sequence numbers. The transmit counters are used in the generation of the transmitted messages and the receive counters are used in the received message out-of-sequence error checking. An out-of-sequence error indicates that a message has been missed.

The host's message sequence numbers independently track the number of messages sent to the MPI 6000. The MPI 6000's message sequence numbers independently track the number of messages sent to the host. These message sequence numbers are used on the receiving end to determine if a message has been missed. See the software communication sequence number controls section for more details.

The host's command sequence numbers for each command group independently track the number of command request messages sent to the MPI 6000. The MPI 6000's command sequence numbers for each command group independently track the number of software flow control and unsolicited status messages sent to the host. These command sequence numbers are used on the receiving end to determine if the appropriate message as specified above has been missed. See the software communication sequence number controls section for more details.

UDP/IP Fast Ethernet Communications Protocol

The UDP/IP fast Ethernet communications protocol implements the UDP/IP fast Ethernet protocol as specified in the *RealFast UDP/IP Core Design Specification* (RealFast Document Number RFHC04026-V042).

Command Request Message

The host sends command request messages to the MPI 6000 as required for system operation. The host and the MPI 6000 uses the following UDP/IP fast Ethernet communications command request message shown here:

```
<len> <msgSeqNum> <cmd> <cmdSeqNum> [<data>] <checksum>
```

where

<len> = length, a word that specifies the number of bytes in the entire message.

<msgSeqNum> = message sequence number, a byte that specifies the message sequence number of the message. See the software communication sequence number controls section for details.

<cmd> = command, a word that specifies the system command. See the command sections for details.

<cmdSeqNum> = command sequence number, a byte that specifies the command sequence number of the message. See the software communication sequence number controls section for details.

[<data>] = optional data payload that varies in length from 0 to 65 bytes and is associated with each specific command. See the command sections for details.

<checksum> = checksum, a byte that specifies the checksum of the message.

Data Acknowledge Message

The MPI 6000 sends data acknowledge messages to the host after receiving command request messages from the host.

The host sends data acknowledge messages to the MPI 6000 after receiving command response messages, asynchronous response messages, software flow control messages and unsolicited status messages from the MPI 6000. The host and the MPI 6000 uses the following UDP/IP fast Ethernet communications data acknowledge message as shown here:

<len> *<msgSeqNum>* *<cmd>* *<cmdSeqNum>* *<resp>* *<msgSeqNumAck>* *<checksum>*

where

<len> - length, word that specifies the number of bytes in the entire message.

<msgSeqNum> - message sequence number, byte that specifies the message sequence number of the message. See the software communication sequence number controls section for details.

<cmd> - command, word that specifies the system command. See the command sections for details.

<cmdSeqNum> - command sequence number, byte that specifies the command sequence number of the message. See the software communication sequence number controls section for details.

<resp> - response, word that specifies the system response. See the response sections for details.

<msgSeqNumAck> - message sequence number acknowledge, byte that specifies the message sequence number of the message being acknowledged. See the software communication sequence number controls section for details.

<checksum> - checksum, byte that specifies the checksum of the message.

Command Response Message

The MPI 6000 after receiving command request messages from the host sends command response messages to the host.

The host and the MPI 6000 uses the following UDP/IP fast Ethernet communications command response message shown here:

<len> <msgSeqNum> <cmd> <cmdSeqNum> <resp> [<data>] <checksum>

where

<len> = length, a word that specifies the number of bytes in the entire message.

<msgSeqNum> = message sequence number, a byte that specifies the message sequence number of the message. See the software communication sequence number controls section for details.

<cmd> = command, word that specifies the system command. See the command sections for details.

<cmdSeqNum> = command sequence number, a byte that specifies the command sequence number of the message. See the software communication sequence number controls section for details.

<resp> = response, a word that specifies the system response. See the response sections for details.

[<data>] = optional data payload that varies in length from 0 to 63 bytes and is associated with each specific response. See the response sections for details.

<checksum> = checksum, a byte that specifies the checksum of the message.

Asynchronous Response Message

The MPI 6000 after receiving command request messages from the host optionally sends asynchronous response messages to the host.

The host and the MPI 6000 uses the following UDP/IP fast Ethernet communications asynchronous response message shown here:

<len> <msgSeqNum> <cmd> <cmdSeqNum> <resp> [<data>] <checksum>

where

<len> = length, a word that specifies the number of bytes in the entire message.

<msgSeqNum> = message sequence number, a byte that specifies the message sequence number of the message. See the software communication sequence number controls section for details.

<cmd> = command, word that specifies the system command. See the command sections for details.

<cmdSeqNum> = command sequence number, a byte that specifies the command sequence number of the message. See the software communication sequence number controls section for details.

<resp> = response, a word that specifies the system response. See the response sections for details.

[<data>] - optional data payload that varies in length from 0 to 63 bytes and is associated with each specific response. See the response sections for details.

<checksum> = checksum, a byte that specifies the checksum of the message.

Software Flow Control Message

The MPI 6000 after receiving command request messages from the host optionally sends software flow control messages to the host as required for system operation.

The host optionally sends software flow control messages to the MPI 6000 as required for host operation.

The host and the MPI 6000 uses the following UDP/IP fast Ethernet communications software flow control message shown here:

`<len> <msgSeqNum> <cmd> <cmdSeqNum> <resp> <checksum>`

where

`<len>` = length, a word that specifies the number of bytes in the entire message.

`<msgSeqNum>` = message sequence number, a byte that specifies the message sequence number of the message. See the software communication sequence number controls section for details.

`<cmd>` = command, a word that specifies the system command. See the command sections for details.

`<cmdSeqNum>` - command sequence number, a byte that specifies the command sequence number of the message. See the software communication sequence number controls section for details.

`<resp>` = response, a word that specifies the system response. See the response sections for details.

`<checksum>` = checksum, a byte that specifies the checksum of the message.

Unsolicited Status Message

The MPI 6000 sends unsolicited status messages to the host as required for system operation.

The host and the MPI 6000 uses the following UDP/IP fast Ethernet communications unsolicited status message shown here:

`<len> <msgSeqNum> <cmd> <cmdSeqNum> <status> [<data>] <checksum>`

where

`<len>` = length, a word that specifies the number of bytes in the entire message.

`<msgSeqNum>` = message sequence number, a byte that specifies the message sequence number of the message. See the software communication sequence number controls section for details.

`<cmd>` = command, a word that specifies the system command. See the command sections for details.

`<cmdSeqNum>` = command sequence number, a byte that specifies the command sequence number of the message. See the software communication sequence number controls section for details.

<status> = status, a word that specifies the system status. See the response sections for details.

[<data>] = optional data payload that varies in length from 0 to 63 bytes and is associated with each specific response. See the response sections for details.

<checksum> = checksum, a byte that specifies the checksum of the message.

Serial Communications Protocol

The serial communications protocol implements the TransCore error correction protocol (ECP) serial standard.

Command Request Message

The host sends command request messages to the MPI 6000 as required for system operation.

The host and the MPI 6000 uses the following serial communications command request message as shown here:

```
<som> <len> <msgSeqNum> <cmd> <cmdSeqNum> [<data>] <crc16> <eom>
```

where

<som> - start of message, byte that specifies the start of the message which is defined as the ASCII character &.

<len> - length, word that specifies the number of bytes in the entire message.

<msgSeqNum> - message sequence number, byte that specifies the message sequence number of the message. See the software communication sequence number controls section for details.

<cmd> - command, word that specifies the system command. See the command sections for details.

<cmdSeqNum> - command sequence number, byte that specifies the command sequence number of the message. See the software communication sequence number controls section for details.

[<data>] - optional data payload that varies in length from 0 to 65 bytes and is associated with each specific command. See the command sections for details.

<crc16> - 16 bit cyclic redundancy check, word that specifies the 16 bit cyclic redundancy check of the message exclusive of the <som> and <eom> bytes. The polynomial for the CRC calculation is $X^{16}+X^{12}+X^5+1$ with a divisor polynome of 1021H and an initial value of FFFFH for a CCITT16 type CRC.

<eom> - end of message, byte that specifies the end of the message which is defined as the ASCII character %.

Data Acknowledge Message

The MPI 6000 after receiving command request messages from the host sends data acknowledge messages to the host.

The host after receiving command response messages, asynchronous response messages, software flow control messages and unsolicited status messages from the MPI 6000 sends data acknowledge messages to the MPI 6000.

The host and the MPI 6000 uses the following serial communications data acknowledge message as shown here:

<som> <len> <msgSeqNum> <cmd> <cmdSeqNum> <resp> <msgSeqNumAck> <crc16> <eom>

where

<som> - start of message, byte that specifies the start of the message which is defined as the ASCII character &.

<len> - length, word that specifies the number of bytes in the entire message.

<msgSeqNum> - message sequence number, byte that specifies the message sequence number of the message. See the software communication sequence number controls section for details.

<cmd> - command, word that specifies the system command. See the command sections for details.

<cmdSeqNum> - command sequence number, byte that specifies the command sequence number of the message. See the software communication sequence number controls section for details.

<resp> - response, word that specifies the system response. See the response sections for details.

<msgSeqNumAck> - message sequence number acknowledge, byte that specifies the message sequence number of the message being acknowledged. See the software communication sequence number controls section for details.

<crc16> - 16 bit cyclic redundancy check, word that specifies the 16 bit cyclic redundancy check of the message exclusive of the <som> and <eom> bytes. The polynomial for the CRC calculation is $X^{16}+X^{12}+X^5+1$ with a divisor polynome of 1021H and an initial value of FFFFH for a CCITT16 type CRC.

<eom> - end of message, byte that specifies the end of the message which is defined as the ASCII character %.

Command Response Message

The MPI 6000 after receiving command request messages from the host sends command response messages to the host.

The host and the MPI 6000 uses the following serial communications command response message as shown here:

<som> <len> <msgSeqNum> <cmd> <cmdSeqNum> <resp> [<data>] <crc16> <eom>

where

<som> - start of message, byte that specifies the start of the message which is defined as the ASCII character &.

<len> - length, word that specifies the number of bytes in the entire message.

<msgSeqNum> - message sequence number, byte that specifies the message sequence number of the message. See the software communication sequence number controls section for details.

<cmd> - command, word that specifies the system command. See the command sections for details.

<cmdSeqNum> - command sequence number, byte that specifies the command sequence number of the message. See the software communication sequence number controls section for details.

<resp> - response, word that specifies the system response. See the response sections for details.

[<data>] - optional data payload that varies in length from 0 to 63 bytes and is associated with each specific response. See the response sections for details.

<crc16> - 16 bit cyclic redundancy check, word that specifies the 16 bit cyclic redundancy check of the message exclusive of the <som> and <eom> bytes. The polynomial for the CRC calculation is $X^{16}+X^{12}+X^5+1$ with a divisor polynome of 1021H and an initial value of FFFFH for a CCITT16 type CRC.

<eom> - end of message, byte that specifies the end of the message which is defined as the ASCII character %.

Asynchronous Response Message

The MPI 6000 after receiving command request messages from the host optionally sends asynchronous response messages to the host.

The host and the MPI 6000 uses the following serial communications asynchronous response message as shown here:

<som> <len> <msgSeqNum> <cmd> <cmdSeqNum> <resp> [<data>] <crc16> <eom>

where

<som> - start of message, byte that specifies the start of the message which is defined as the ASCII character &.

<len> - length, word that specifies the number of bytes in the entire message.

<msgSeqNum> - message sequence number, byte that specifies the message sequence number of the message. See the software communication sequence number controls section for details.

<cmd> - command, word that specifies the system command. See the command sections for details.

<cmdSeqNum> - command sequence number, byte that specifies the command sequence number of the message. See the software communication sequence number controls section for details.

<resp> - response, word that specifies the system response. See the response sections for details.

[<data>] - optional data payload that varies in length from 0 to 63 bytes and is associated with each specific response. See the response sections for details.

<crc16> - 16 bit cyclic redundancy check, word that specifies the 16 bit cyclic redundancy check of the message exclusive of the *<som>* and *<eom>* bytes. The polynomial for the CRC calculation is $X^{16}+X^{12}+X^5+1$ with a divisor polynomial of 1021H and an initial value of FFFFH for a CCITT16 type CRC.

<eom> - end of message, byte that specifies the end of the message which is defined as the ASCII character %.

Software Flow Control Message

The MPI 6000 after receiving command request messages from the host optionally sends software flow control messages to the host as required for system operation.

The host optionally sends software flow control messages to the MPI 6000 as required for host operation.

The host and the MPI 6000 uses the following serial communications software flow control message as shown here:

<som> *<len>* *<msgSeqNum>* *<cmd>* *<cmdSeqNum>* *<resp>* *<crc16>* *<eom>*

where

<som> - start of message, byte that specifies the start of the message which is defined as the ASCII character &.

<len> - length, word that specifies the number of bytes in the entire message.

<msgSeqNum> - message sequence number, byte that specifies the message sequence number of the message. See the software communication sequence number controls section for details.

<cmd> - command, word that specifies the system command. See the command sections for details.

<cmdSeqNum> - command sequence number, byte that specifies the command sequence number of the message. See the software communication sequence number controls section for details.

<resp> - response, word that specifies the system response. See the response sections for details.

<crc16> - 16 bit cyclic redundancy check, word that specifies the 16 bit cyclic redundancy check of the message exclusive of the *<som>* and *<eom>* bytes. The polynomial for the CRC calculation is $X^{16}+X^{12}+X^5+1$ with a divisor polynome of 1021H and an initial value of FFFFH for a CCITT16 type CRC.

<eom> - end of message, byte that specifies the end of the message which is defined as the ASCII character %.

Unsolicited Status Message

The MPI 6000 sends unsolicited status messages to the host as required for system operation.

The host and the MPI 6000 uses the following serial communications unsolicited status message as shown here:

```
<som> <len> <msgSeqNum> <cmd> <cmdSeqNum> <status> [<data>] <crc16> <eom>
```

where

<som> - start of message, byte that specifies the start of the message which is defined as the ASCII character &.

<len> - length, word that specifies the number of bytes in the entire message.

<msgSeqNum> - message sequence number, byte that specifies the message sequence number of the message. See the software communication sequence number controls section for details.

<cmd> - command, word that specifies the system command. See the command sections for details.

<cmdSeqNum> - command sequence number, byte that specifies the command sequence number of the message. See the software communication sequence number controls section for details.

<status> - status, word that specifies the system status. See the response sections for details.

[<data>] - optional data payload that varies in length from 0 to 63 bytes and is associated with each specific response. See the response sections for details.

<crc16> - 16 bit cyclic redundancy check, word that specifies the 16 bit cyclic redundancy check of the message exclusive of the <som> and <eom> bytes. The polynomial for the CRC calculation is $X^{16}+X^{12}+X^5+1$ with a divisor polynomial of 1021H and an initial value of FFFFH for a CCITT16 type CRC.

<eom> - end of message, byte that specifies the end of the message which is defined as the ASCII character %.

PRELIMINARY

Configuration Commands and Responses

PRELIMINARY

Configuration Commands and Responses

This chapter describes the MPI 6000 interface commands that are used to configure the reader.

Configuring the MPI 6000

MPI 6000 Readers have been preconfigured for most needed operations. Parameters such as attenuation, step-lock settings, and tag command sequences are set when the reader powers up. The Set Frequency command is the only required configuration command. You must issue this command before the MPI 6000 Reader can read tags.

Required Commands to Set Up MPI 6000 Reader

This section describes the configuration commands that are used to set up the MPI 6000.

Set Frequency

This section describes the Set Frequency command that is used to set the MPI 6000 frequency. Figure 7-1 shows the command transaction process. Table 7-1 lists the Set Frequency command data.

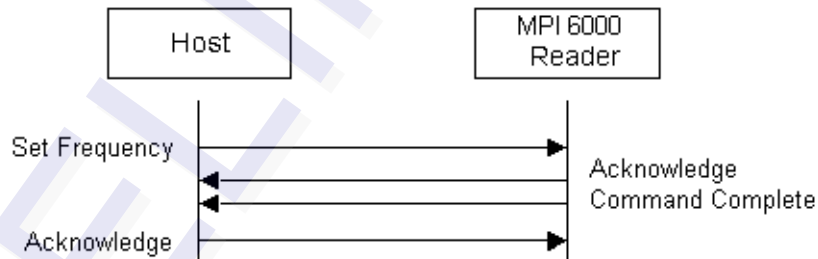


Figure 7-1 Set Frequency Command Process

This command sets the A Counter and B Counter least significant bits (LSB) for the specified source.

Table 7-1 Set Frequency Command Parameters

Set Frequency Command Data								Data Payload
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
Set Frequency Command								08H
Unused							Source	0XH

Table 7-1 Set Frequency Command Parameters

Unused	A Counter	XXH
Unused	B Counter LSBs	0XH
Carriage Return		0DH

Table 7-2 shows the Set Frequency Response parameters.

Table 7-2 Set Frequency Response Parameters

Set Frequency Response Data								Data Payload
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
Set Frequency Command								08H
Unused							Source	0XH
Acknowledge								00H
Carriage Return								0DH

The Source field identifies the source for the associated N Counter information (Table 7-3).

Table 7-3 Descriptions of Sources

Source	Definition
0	Source 1
1	Source 2

A Counter – This field contains the data for the binary five-bit A Counter of the PLL. The A and B counters combine to form the 18-bit N Counter. The valid range of the A Counter data field is 00H to 1FH.

B Counter LSBs – This field contains the LSB for the binary 13-bit B Counter of the PLL. The A and B counters combine to form the 18-bit N Counter. The valid range of the data field is 0H to 3H. The B Counter value is 007XH, where X = B Counter LSBs.

The PLL frequency spreadsheet contains the values used to set the A Counter and the B Counter. This command will be modified to allow the system to send frequency values instead of A and B counters.

System Interface Command Group Commands

This section describes the system commands used to configure the MPI 6000.

Table 7-4 System Interface Command Group

System Interface Command	Command Code
System Identify	0000H
Set Communications Baud Rate	0001H
Get Communications Baud Rate	0002H
Set Time and Date	0003H
Get Time and Date	0004H
Firmware Download	0005H
Reset Reader	0006H
Get Stored Tag Response Message	0007H
Get Number of Stored Tag Response Messages	0008H
Delete All Stored Tag Response Messages	0009H
Get System Startup Status	000AH
Get Lane Controller Interface Status	000BH
Get System Interface Status	000CH
Get DigBrd Hdw Remote Inventory	000DH
Get DigBrd CPU Boot Fmwr Remote Inventory	000EH
Get DigBrd CPU Appl Fmwr Remote Inventory	000FH
Get DigBrd FPGA UDP/IP Core Fmwr Remote Inventory	0010H
Set UDP/IP Core Lane Controller IP Address and Port Number Parameters	0011H
Get UDP/IP Core Lane Controller IP Address and Port Number Parameters	0012H
Set UDP/IP Core IP Address	0013H
Get UDP/IP Core IP Address	0014H
Get UDP/IP Core UDP Port Number	0015H

Each of the system command group commands is listed in this section.

System Identify

System Identify Command Data	Data Payload
System Identify Command	0000H

System Identify Response Data	Data Payload
System Identify Command	0000H
Vendor Name	
Version ID	
Part Number	
Serial Number	

System Identify Data Sizes

System Identify Data	Data Size
Vendor Name	15 Bytes
Version ID	15 Bytes
Part Number	15 Bytes
Serial Number	15 Bytes

Set Communications Baud Rate

Set Communications Baud Rate Command Data	Data Payload
Set Communications Baud Rate Command	0001H
Baud Rate Data Code	XXH

Set Communications Baud Rate Response Data	Data Payload
Set Communications Baud Rate Command	0001H

Baud Rate Data Codes

Baud Rate	Data Code
19,200 bps	0CH
38,400 bps (System Default)	0DH
57,600 bps	0EH
115,200 bps	0FH

Get Communications Baud Rate

Get Communications Baud Rate Command Data	Data Payload
Get Communications Baud Rate Command	0002H

Get Communications Baud Rate Response Data	Data Payload
Get Communications Baud Rate Command	0002H
Baud Rate Data Code	XXH

Set Time and Date

Set Time and Data Command Data	Data Payload
Set Time and Date Command	0003H
Hours	XXH
Minutes	XXH
Seconds	XXH
Hundredths of Seconds	XXH
Month	XXH
Day	XXH
Year	XXH

Set Time and Data Response Data	Data Payload
Set Time and Date Command	0003H

Time and Date Data Ranges

Time and Date Data	Data Range
Hours	0 to 23 (00H to 17H)
Minutes	0 to 59 (00H to 3BH)
Seconds	0 to 59 (00H to 3BH)
Hundredths of Seconds	0 to 99 (00H to 63H)
Month	1 to 12 (01H to 0CH)
Day	1 to 31 (01H to 1FH)
Year	0 to 99 (00H to 63H)

Get Time and Date

Get Time and Date Command Data	Data Payload
Get Time and Date Command	0004H

Get Time and Date Response Data	Data Payload
Set Time and Date Command	0004H
Hours	XXH
Minutes	XXH
Seconds	XXH
Hundredths of Seconds	XXH
Month	XXH
Day	XXH
Year	XXH

Firmware Download

Firmware Download Command Data	Data Payload
Firmware Download Command	0005H

Firmware Download Response Data	Data Payload
Firmware Download Command	0005H

The Firmware Download command is implemented as defined for both UDP/IP Fast Ethernet and serial communications.

Reset Reader

Reset Reader Command Data	Data Payload
Reset Reader Command	0006H
Reset Reader Control Word	A5A5H

Reset Reader Response Data	Data Payload
Reset Reader Command	0006H

Get Stored Tag Response Message

Get Stored Tag Response Message Command Data	Data Payload
Get Stored Tag Response Message Command	0007H
Stored Tag Response Message Number	XXXXH

Get Stored Tag Response Message Response Data	Data Payload
Get Stored Tag Response Message Command	0007H
Stored Tag Response Message Number	XXXXH
Stored Tag Response Message Data	

Get Number of Stored Tag Response Messages

Get Number of Stored Tag Response Messages Command Data	Data Payload
Get Number of Stored Tag Response Messages Command	0008H

Get Number of Stored Tag Response Messages Response Data	Data Payload
Get Number of Stored Tag Response Messages Command	0008H
Number of Stored Tag Response Messages	XXXXH

Delete All Stored Tag Response Messages

Delete All Stored Tag Response Messages Command Data	Data Payload
Delete All Stored Tag Response Messages Command	0009H
Delete All Stored Tag Response Messages Control Word	A5A5H

Delete All Stored Tag Response Messages Response Data	Data Payload
Delete All Stored Tag Response Messages Command	0009H

Get System Startup Status

Get System Startup Status Command Data	Data Payload
Get System Startup Status Command	000AH

Get System Startup Status Response Data	Data Payload
Get System Startup Status Command	000AH
System Startup Module Number (System Initialization)	XXXXH
System Timer Initialization Status Error Number	XXXXH
System BMU Initialization Status Error Number	XXXXH
System Queue Create Status Error Number	XXXXH
System Task Create Status Error Number	XXXXH

Get Lane Controller Interface Status

Get Lane Controller Interface Status Command Data	Data Payload
Get Lane Controller Interface Status Command	000BH

Get Lane Controller Interface Status Response Data	Data Payload
Get Lane Controller Interface Status Command	000BH
Module Number	XXXXH
Error Number	XXXXH

Get System Interface Status

Get System Interface Status Command Data	Data Payload
Get System Interface Status Command	000CH

Get System Interface Status Response Data	Data Payload
Get System Interface Status Command	000CH
Module Number	XXXXH
Error Number	XXXXH

Get DigBrd Hdwr Remote Inventory

Get Digital Board Hardware Remote Inventory Command Data	Data Payload
Get Digital Board Hardware Remote Inventory Command	000DH

Get Digital Board Hardware Remote Inventory Response Data	Data Payload
Get Digital Board Hardware Remote Inventory Command	000DH
Vendor Name	
Version ID	
Part Number	
Serial Number	

Hardware Remote Inventory Data Sizes

Hardware Remote Inventory Data	Data Size
Vendor Name	15 Bytes
Version ID	15 Bytes
Part Number	15 Bytes
Serial Number	15 Bytes

Get DigBrd CPU Boot Fmwr Remote Inventory

Get Digital Board CPU Boot Firmware Remote Inventory Command Data	Data Payload
Get Digital Board CPU Boot Firmware Remote Inventory Command	000EH

Get Digital Board CPU Boot Firmware Remote Inventory Response Data	Data Payload
Get Digital Board CPU Boot Firmware Remote Inventory Command	000EH
Vendor Name	
Version ID	
Part Number	

Get DigBrd CPU Appl Fmwr Remote Inventory

Get Digital Board CPU Application Firmware Remote Inventory Command Data	Data Payload
Get Digital Board CPU Application Firmware Remote Inventory Command	000FH

Get Digital Board CPU Application Firmware Remote Inventory Response Data	Data Payload
Get Digital Board CPU Application Firmware Remote Inventory Command	000FH
Vendor Name	
Version ID	
Part Number	

Get DigBrd FPGA UDP/IP Core Fmwr Remote Inventory

Get Digital Board FPGA UDP/IP Core Firmware Remote Inventory Command Data	Data Payload
Get Digital Board FPGA UPD/IP Core Firmware Remote Inventory Command	0010H

Get Digital Board FPGA UDP/IP Core Firmware Remote Inventory Response Data	Data Payload
Get Digital Board FPGA UPD/IP Core Firmware Remote Inventory Command	0010H
Vendor Name	
Version ID	
Part Number	

Firmware Remote Inventory Data Sizes

Firmware Remote Inventory Data	Data Size
Vendor Name	15 Bytes
Version ID	15 Bytes
Part Number	15 Bytes

Set UDP/IP Core Lane Controller Parameters

Set UDP/IP Core Lane Controller Parameters Command Data	Data Payload
Set UDP/IP Core Lane Controller Parameters Command	0011H
IP Address (MSW)	XXXXH
IP Address (LSW)	XXXXH
Port Number	XXXXH

Set UDP/IP Core Lane Controller Parameters Response Data	Data Payload
Set UDP/IP Core Lane Controller Parameters Command	0011H

Get UDP/IP Core Lane Controller Parameters

Get UDP/IP Core Lane Controller Parameters Command Data	Data Payload
Get UDP/IP Core Lane Controller Parameters Command	0012H

Get UDP/IP Core Lane Controller Parameters Response Data	Data Payload
Get UDP/IP Core Lane Controller Parameters Command	0012H
IP Address (MSW)	XXXXH
IP Address (LSW)	XXXXH
Port Number	XXXXH

Set UDP/IP Core IP Address

Set UDP/IP Core IP Address Command Data	Data Payload
Set UDP/IP Core IP Address Command	0013H
IP Address (MSW)	XXXXH
IP Address (LSW)	XXXXH

Set UDP/IP Core IP Address Response Data	Data Payload
Set UDP/IP Core IP Address Command	0013H

Get UDP/IP Core IP Address

Get UDP/IP Core IP Address Command Data	Data Payload
Get UDP/IP Core IP Address Command	0014H

Get UDP/IP Core Lane Controller Parameters Command Data	Data Payload
Get UDP/IP Core IP Address Command	0014H
IP Address (MSW)	XXXXH
IP Address (LSW)	XXXXH

Get UDP/IP Core Port Number

Get UDP/IP Core Port Number Command Data	Data Payload
Get UDP/IP Core Port Number Command	0015H

Get UDP/IP Core Port Number Command Data	Data Payload
Get UDP/IP Core Port Number Command	0015H
Port Number	XXXXH

Tag Command Processing

PRELIMINARY

Tag Command Processing

This chapter provides definitions of and instructions for reading from and writing to a tag, as well as explanations of the tag command codes.

Reader Operation

The reader can operate in one of two command sequences, either read or write. The tag command sequences for the Read and Write operations are detailed in the following sections.

Write Commands

To be provided.

Read Commands

To be provided

Host Commands Required for Tag Processing

To be provided.

PRELIMINARY

PRELIMINARY

System Diagnostics and
Preventive Maintenance

PRELIMINARY

System Diagnostics and Preventive Maintenance

This chapter provides information on the following subjects:

Error Messages

Troubleshooting

Preventive Maintenance Schedule

Visual Inspection

MPI 6000 Repair

Removal and Replacement Procedures

Technical Support

Troubleshooting Indications and Actions

To be provided.

PRELIMINARY

A

Acronyms and Glossary

PRELIMINARY

Acronyms and Glossary

A

AC alternating current

ACK acknowledge (data valid)

antenna passive device that converts RF energy into magnetic energy (RF signal)

ATA American Trucking Associations refers to a standard RF communications protocol and data storage method. ATA-type tags are read only.

AVI automatic vehicle identification

B

backscatter portion of an RF signal that is modulated by a tag and radiated back to the reader

baud measure of number of bits per second of a digital signal; for example, 9600
baud = 9600 bits per second

bit The smallest unit of information, consisting of a 0 or 1, that is formed from a binary digit

byte binary character; for example, one 8-bit ASCII character

C

cm centimeter(s)

command data set that is recognized by the receiving device as intending to elicit a specific response

CRC cyclic redundancy check

CTRL control

CTS clear to send

D

data information that is processed by a computing device

DC	direct current
dB	decibel(s)
dB_i	decibel(s), referencing isotropic radiator
E	
ECP	error correcting protocol
eGo	Proprietary name for ANS INCITS 256-2001 and ISO 18000-6 compliant TransCore products. A registered trademark of TC IP, Ltd.
eom	end of message
EEPROM	electrically erasable programmable read-only memory
ESD	electrostatic discharge
F	
FCC	Federal Communications Commission
field	physical area/space in which a tag can be read by the reader; also, an element of a data record/frame, for example, division within a tag's data frame
frame	consecutive bits of data in memory that are read and written as a group
frequency bands	range of RF frequencies assigned for transmission by an RF device
ft	foot or feet
H	
hex	hexadecimal
hexadecimal	base 16 numbering system that uses the characters 0 through 9 and A through F to represent the digits 0 through 15
host	device, generally a computer, that is connected to reader system components through the communications port
Hz	hertz

I

I/O	input/output
IAG	Inter-Agency Group, distributor of IAG tags
ID	identification; encoded information unique to a particular tag
in	inch(es)
interface	connection point for communications with another device
IRQ	interrupt request

J

JP	jumper pin
-----------	------------

K

k	kilo (10^3)
kg	kilogram(s)

L

lane controller	device that is used to integrate all activity that occurs in a toll lane.
lb	pound(s)
LED	light-emitting diode

M

message	combination of fields, frames, and pages as required by the system to transmit or receive associated command and response data to and from the reader and host computer
m	meter(s)
mA	milliamp(s)
Mega	million (10^6)
MB	megabyte(s)
MHz	megahertz

MPI 6000 Multi-Protocol Reader System Guide

milli	one-thousandth (10^{-3})
mode	method of operation
MPI	TransCore's Multi-Protocol Reader
ms	milliseconds
mW	milliwatt(s)
N	
NEMA	National Electrical Manufacturers Association
O	
OSHA	Occupational Safety and Health Administration
P	
PC	personal computer
PLL	phase-lock loop
protocol	specified convention for the format of data messages communicated between devices
PWA	printed wiring assembly
R	
RAM	random access memory
read	process of acquiring data from a device, for example, from a tag or from computer memory
reader	controlled interrogating device capable of acquiring data from a device, for example, acquiring and interrupting data from a tag
read zone	physical area in which a tag can be read by the reader system
RF	radio frequency
RFID	radio frequency identification
RTS	request to send

S

s	second(s)
SeGo	SeGo is a superset of the TransCore eGo protocol.
SRAM	static random access memory
som	start of message
system	a reader, RF module, antenna, and tag, which are described by the general application and interfaces with each other and any connected devices that are defined as being outside the system.

T

tag	small, self-contained device acting as an identifying transponder
TDM	time-division multiplexing, used in this document to refer to the use of time-division multiplexing of multiple readers in proximity of each other.
Title 21	state of California code of regulations, Chapter 16, Title 21, which is the standard used for AVI/DSRC (digital short-range communications) protocol
toll	any application of the system equipment wherein the equipment is used to assist in the orderly collection of money in exchange for the passage of a vehicle through a particular installation point
TrAC	TransCore Action Center
transponder	a tag

U

UART	universal asynchronous receiver-transmitter
UTA	universal toll antenna

V

v	volt(s)
VCC	voltage controlled current
Ver	version (software)

W

W

watt(s)

write

process of recording data, for example, writing to computer memory or to a tag's memory. Writing erases previous data stored at the specified memory locations.

PRELIMINARY

B

Block Diagrams

PRELIMINARY

Appendix B

Block Diagrams

This appendix shows the block diagrams for the interface connections between the components as well as the individual MPI 6000 System components.

MPI 6000 System

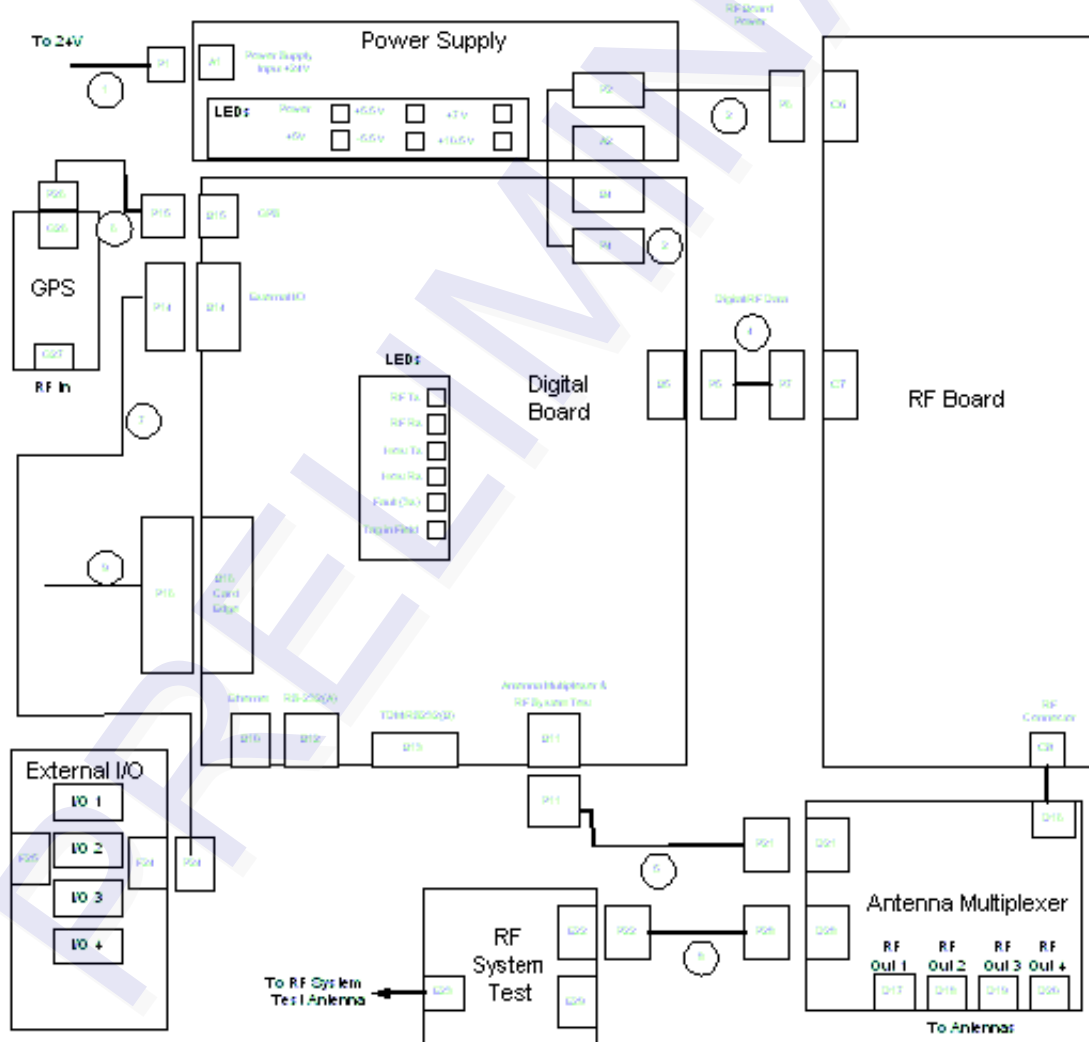


Figure B-1 MPI 6000 Hardware Interconnection Block Diagram

PRELIMINARY

C

System Technical Specifications

PRELIMINARY

System Technical Specifications

This appendix provides reference information for the MPI 6000 System components.

Component Specifications

This appendix describes the engineering specifications for the MPI 6000 System components.

MPI 6000 Multi-Protocol Reader

Power Supply Fault Detection

Each voltage supply has fault detection to determine if the voltage supply is functioning correctly. Output tolerance is tested to ± 5 percent. If any of the voltage supplies fail, the fault signal from the power supply to the digital board defaults to low.

AA3152 Universal Toll Antenna

The AA3152 antenna specifications are as follows:

- Operates in the location and monitoring service band (902 to 928 MHz).
- Optimum radiation pattern — Virtually no side or back lobes help to confine antenna coverage to a single lane.
- Weatherproof — Each antenna is housed in a radome made of materials with favorable electrical characteristics and resistance to ultraviolet radiation.
- Bandpass filtering helps to attenuate interference from other RF sources.

Environmental Specifications

The AA3152 UTAs can withstand the environmental tolerances shown in Table C-1.

Table C-1 Antenna Environmental Tolerances

Environment	Specification
Dust	NEMA pub 250-1991, Sec. 6.5, page 18
Rain	NEMA pub 250-1991, Sec. 6.4, page 17 and Sec. 6.7, page 19
Corrosion resistance	NEMA pub 250-1991, Sec. 6.9, page 20
Shock	5 G ½-sine pulse, 10 ms duration, 3 axes
Vibration	0.5 G _{rms} 10-500 Hz
Temperature range	-40°F to +167°F (-40°C to +75°C)
Humidity	100% condensing

D

Hardware Interfaces

PRELIMINARY

Hardware Interfaces

This appendix describes the physical interconnections within an MPI 6000 System.

Hardware Interfaces

This appendix describes the hardware interfaces in the MPI 6000 and to external components, such as antennas.

Figure D-1 shows the basic hardware interconnections for the MPI 6000.

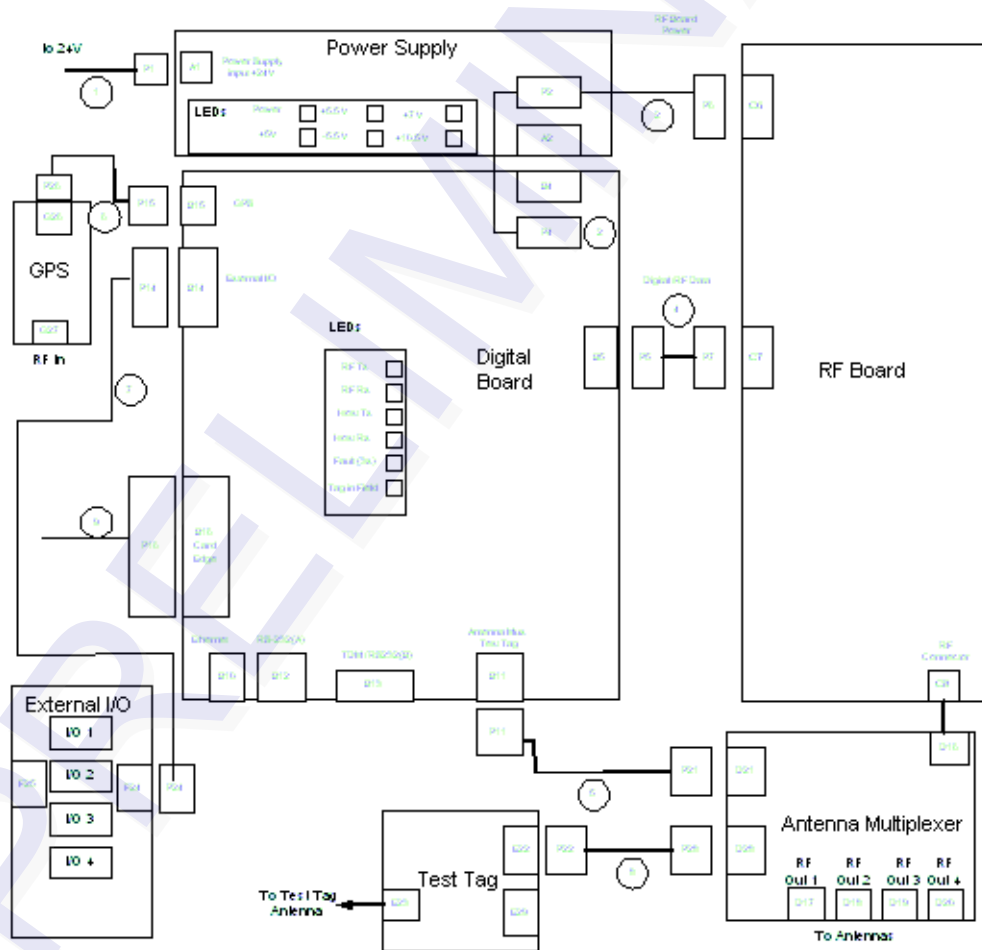


Figure D-1 MPI 6000 Hardware Interconnection Block Diagram

Communications

The MPI 6000 communicates with a host via Ethernet or serial communications.

Ethernet

The connector is an RJ-45 jack. This interface is 10-base T. Table D-1 lists the pin-outs.

Table D-1 Ethernet Connector Pin-outs

Pin	Signal	Description
1	TPTX+	Output Differential Transmit Data (+)
2	TPTX-	Output Differential Transmit Data (-)
3	TPRX+	Input Differential Receive Data (+)
4	Not connected	N/A
5	Not connected	N/A
6	TPRX-	Input Differential Receive Data (-)
7	Not connected	N/A
	Not connected	N/A

RS-232 Connectors

Table D-2 RS-232A Communications Connector Parameters

Pin	Signal	Description
1	RSD	Received line signal detect (not connected)
2	RXD	Receive Data
3	TXD	Transmit Data
4	DTR	Data Terminal Ready (not connected)
5	GND	Ground
6	DSR	Data Set Ready (not connected)
7	RTS	Request to Send
8	CTS	Clear to Send
9	RI	Ring indicator (not connected)

Table D-3 RS-232B/TDM Connector Parameters

Pin	Signal	Description
1	TXD	Transmit Data
2	RXD	Receive Data
3	DTR	Data Terminal Ready (not connected)
4	RTS	Request to Send
5	CTS	Clear to Send
6	GND	Ground
7	TDM +	TDM positive signal
8	TDM -	TDM negative signal

Table D-4 RS-232 Diagnostics Connector Parameters

Pin	Signal	Description
1	5V PWR	5V power supply for I/O board
2	GND	GND
3	I/O Signal 1	
4	I/O Signal 2	
5	I/O Signal 3	
6	I/O Signal 4	
7	Tag in Field 1	Contact Closure 1 for Tag in Field Signal
8	Tag in Field 2	Contact Closure 2 for Tag in Field Signal

Hardware Diagnostic Port

Table D-5 MPI 6000 Hardware Diagnostic Port Parameters

Pin	Signal	Source	Description
1	I	RF	I Channel from RF receiver
2	Q	RF	Q Channel from RF receiver
3	RSSI	RF	RSSI Detector Output, high for I low for Q.
4	RANGE_ADJ_CNTL	RF	Range Adjust_Control Signal
5	+3.3V	Digital	+3.3V
6	Spare	RF	
7	GND		Ground
8	Spare	RF	
9	Spare	RF	
10	IAG_New_Sig_Det	RF	IAG New Signal Detection Line
11	IAG	RF	IAG Channel from RF receiver
12	GND		Ground
13	Config Type 0	Digital	Configuration Selection bit 1
14	Config Type 1	Digital	Configuration Selection bit 2
15	Config Type 2	Digital	Configuration Selection bit 3
16	Config Type 3	Digital	Configuration Selection bit 4
17	Tag Type Ack	RF	Acks the tag type inputs and indicates that the DL & DOM DACS are settled.
18	Ready to Tx	RF	Ready to Transmit
19	Config Load	Digital	Signal to RF to load new config.
20	MOD	Digital	RF Modulation Signal
21	RF ON/OFF	Digital	RF On Off Control
22	UL/DL Cntrl	Digital	Controls whether active source is Uplink or Downlink
23	TDM	Digital	TDM Sync Pulse
24	GPS 1pps	Digital	1 pulse per second signal for Frequency stabilization
25	Error (txcvr fault)	RF	RF Error Indicator active low
26	Power Supply Fault	Digital	Fault Signal from the Power Supply Board

Table D-5 MPI 6000 Hardware Diagnostic Port Parameters (continued)

27	GND		Ground
28	Tx Serial Comm	Digital	Transmit Serial Signal
29	Rx Serial Comm	RF	Receive Serial Signal
30	GoodTagRead	Digital	Active High Pulse from FPGA1
31	CRC Failed	Digital	Active High Pulse from FPGA1
32	ActivatePort	Digital	Enable the Test Port Buffer when the Connector plugged in
33	GND		Ground
34	SW1	Digital	GPIO from MPC852
35	SW2	Digital	GPIO from MPC852
36	SW3	Digital	GPIO from MPC852
37	SW4	Digital	GPIO from MPC852
38	DecoderOutput	Digital	Decoder Bit Stream from FPGA1
39	PLL Clock (decoder)	Digital	PLL Clock from FPGA1
40	GND	Digital	Ground

Antenna Multiplexer Connectors

The antenna multiplexer is used to drive multiple antennas in multiple AVI lanes.

Table D-6 Antenna Multiplexer Connector Pin-outs

Connector	Designator	Pin	Signal	Description
D16	RF input1	1	RF Input/Output	RF input/output signal
D17	RF output 1	1	RF Input/Output	RF input/output signal
D18	RF output 2	1	RF Input/Output	RF input/output signal
D19	RF output 3	1	RF Input/Output	RF input/output signal
D20	RF output 4	1	RF Input/Output	RF input/output signal

Connector D21 is the same as connector B11 on the digital board. Connector D28 is the same as connector B11 on the digital board. This connector is used to connect the data cables from the MPI 6000 to the antenna multiplexer and the RF System Test boards.

RF System Test Connectors

The RF system test checks the ...

- Connector E22, RF system test data is the same as connector B11 on the digital board.
- Connector E29, RF system test data is the same as connector B11 on the digital board. This connector is used to connect the data cables from the MPI 6000 to the antenna multiplexer board and the RF system test boards.
- Connector E23 is the RF in signal.

Table D-7 RF System Test Connector Pin-out

Pin	Signal	Description
1	RF Input/Output	RF input output signal