Overview

The EPCglobal™-certified Speedway™ IPJ-R1000 is a fixed Gen 2 UHF RFID tag reader that provides network connectivity between tag data and enterprise system software.

A key element of Impinj's GrandPrix™ RFID system solution, Speedway is the first high-performance reader designed from the ground up to support the EPCglobal Gen 2 standard in its entirety. That includes the accommodation of 640 kbps tag-to-reader data rates, robust performance in dense-reader environments (without the requirement for network synchronization), the elimination of ghost reads, and more. Combined with an extensible architecture that supports seamless integration of field-upgradeable, third party application software, Speedway is the most adaptable reader solution available today.

This user guide provides instructions on how to install, configure, operate, and troubleshoot the Speedway reader. It assumes the user is familiar with appropriate networking facilities, the EPCglobal™ Gen 2 specification, and general principles of RFID system management.

PRELIMINARY USER GUIDE

Federal Communications Commission (FCC) Compliance

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna
- Increase the separation between the equipment and receiver
- Consult the dealer or an qualified radio/TV technician for assistance

Note: Changes to this product will void the user's authority to operate per FCC Part 15.

Industry Canada (IC) Compliance

Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

This device has been designed to operate with the antenna(s) listed in the section entitled, "Connecting the Antenna(s)," and having a maximum gain of 6 dB. Antennas not included in this list or having a gain greater than 6 dB are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.

Note: The term "IC:" before the radio certification number only signifies that Industry of Canada technical specifications were met.

Before You Begin

Please read this document in its entirety before operating the Speedway reader, as serious personal injury and/or equipment damage may result from improper use.

Unpacking the Speedway Reader

Your Speedway reader has been shipped with the following:

• Speedway reader unit
• Power supply module (CUI, Inc., P/N DTS240259U-P11P-DB) with 24VDC output (power supply module ordered separately). Note: the use of any other power supply module may cause damage to the reader

Other System and Equipment Requirements

The components and accessories detailed below are required in order to ensure compliance with the Speedway reader. It is the responsibility of the user or professional installer to provide and properly use all these components and accessories:

• A PC running Windows 2000 or higher or XP and
     - An available RS-232 serial port
     - An Ethernet port
• Standard, grounded DB9 serial cable
• Standard Ethernet cable(s)
• TCP/IP network equipment, as required to connect the reader to a PC
• Impinj-approved UHF RFID antenna(s), including associated RF cable with RP-TNC male connector interface
• http browser that includes Java Runtime Environment (JRE) of version 1.4.2 or later. Note that Windows 2000 default is 1.3.1. The latest version of JRE can be downloaded from: **http://java.com/en/download/manual.jsp**

Speedway Reader I/O Ports

Refer to Figure 1 for the Speedway reader's major ports, connectors, and status indicators, which are clearly indicated on the unit. The Speedway reader is equipped with the following ports:

• RJ-45 Ethernet jack (labeled 10/100 BASE-T)
• Four female RP-TNC RF antenna connectors (ANT1 – ANT4)
• Female DB-9 connector for serial communication (SERIAL)
• Female DB-25 connector with user I/O capability (GPIO: RS-232 serial, four 3.3/5V logic inputs, eight 3.3V logic outputs).

The LEDs indicate power (red), status (yellow), and antenna activity (red). Note that the LEDs that correspond to the connected antenna(s) only light when active (transmitting).
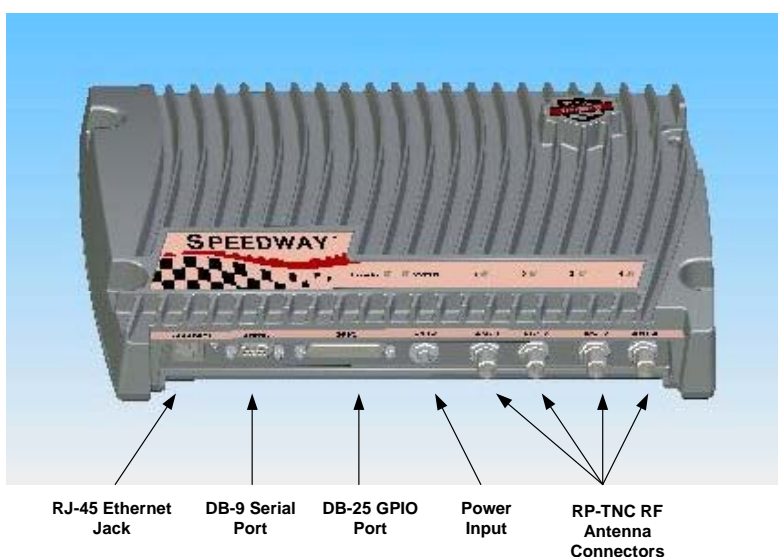

Figure 1 Impinj Speedway Reader Port Connections

Mounting the Speedway Reader

When securing the unit with #10 screws via the four mounting brackets, the Speedway reader may be mounted horizontally or vertically on a stable surface where it will be safe from disturbance. Keep the unit away from direct sunlight, high humidity, extreme temperatures, vibration, and sources of electromagnetic interference, as any combination of these conditions may degrade performance or shorten the life of the unit.

Connecting the Antenna(s)

Do not apply power prior to making the required antenna connections, and always power down the reader before removing an antenna port connection.

The Speedway reader is equipped with four (4) independent, bidirectional, full duplex TX/RX ports, which must be cabled to their respective, Impinj-approved antennas prior to power-up. Unused antenna ports must be left unconnected; they should not be terminated.

Note: Reader power has been factory preset to 30 dBm to accommodate an antenna with 6 dBi composite gain (inclusive of cabling). The Speedway reader may only be operated with Impinj-approved antennas and can radiate no more than 36 dBm EIRP per FCC Part 15.247 regulations. To obtain the maximum allowable reader power setting, the following expression should be used:

Speedway power setting (in dBm) = 36 – Antenna Gain (in dBi)

where the antenna gain includes the loss of the associated cable from the reader to the antenna.

Approved antenna vendors, model numbers, gain characteristics, and associated RF cable/connector include:

• Cushcraft Model Number S9028PCL/R (left- or right-hand CP); 6 dBi gain, with integrated pigtail to RP-TNC female connector

Connecting Power

Connect the power plug into the reader's DC power input and secure the threaded locking jack. When the DC connection is secure, connect the AC power plug into a suitable 100-240 VAC, 50-60 Hz power outlet. The reader will begin its boot sequence.

Note: normal boot time for the reader's operating system is ~20 seconds. The reader cannot be commanded until the boot sequence is complete.

Connecting & Configuring the Network Interface

Reader control is accomplished via either TCP/IP (Ethernet) or serial (RS-232) interfaces on the Speedway unit.

Preparing the IP Interface

Before power-up, connect the reader to your network via the Ethernet port. If your network is capable of communicating to the reader in its default IP configuration, then no serial interface is required.

Connect the PC's Ethernet port to the Speedway reader using one of the following two methods:
• Use of a single Ethernet crossover cable with PC IP address set to a static value (e.g., 192.168.1.10) within the subnet of the reader.
• Use of an Ethernet router or switch with either PC IP address set to a static address within the subnet of the reader (switch) or router's DHCP set to provide the PC with an IP address within the reader's subnet.

To verify correct TCP/IP connectivity ping (using the "ping" command) or traceroute (using the "traceroute" command in a Linux environment, or the "tracert" command in a Windows environment) the reader's IP address using the PC's command line interface. Open the PC's web browser application and connect to the reader's hosted webpage (e.g., http://192.168.1.10). To get to the reader's command line interface, use SSH Client or Telnet Client software.

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Default login (case-sensitive) is as follows:

User Name: **root**
Password: **impinj**

Preparing the Serial Interface

Serial communication with the reader can be used at any time in conjunction with, or in lieu of, Ethernet connectivity in order to configure the reader. The serial interface may be necessary to establish initial communications with the Speedway reader if your network equipment is not compatible with the default network configuration of the reader. In this case, the reader's network connection can be configured using the serial port; Ethernet connectivity can then be used for control thereafter, if desired.

To begin, launch HyperTerminal on a PC via the serial port (or a similar communication program, such as minicom in Linux) to establish serial reader communication. Configuration settings are entered via the command line interface, the prompt for which appears when the reader is connected to the PC via the serial interface port. Set the communication parameters of the terminal software as follows:

- Data rate: 115200 bps
- Data bits: 8
- Parity: None
- Stop bits: 1
- Flow control: None

Configuring the Network via the Command Line Interface

Whether using HyperTerminal (Serial Interface), SSH (IP Interface), or Telnet (IP Interface), log in with the same user name and password indicated earlier.

The syntax for setting the reader's host name is as follows:

platformname <host name>

Configuring the Speedway reader for use within existing network environments is done via the **netconf** utility, which resides on the reader. The three configuration modes, accessed via the **netconf** utility, include:

1. Static configuration mode
2. Dynamic configuration mode without a record
3. Dynamic configuration mode with a record

Static Configuration Mode
To set a static IP configuration, use:

netconf <IP address> [optional parameters]

The first parameter to the utility must be the actual IP address for the reader to be used on the network, expressed in dotted-quad notation (e.g., 192.168.20.100). The parameters shown in Table 1 are optional qualifiers for the remaining networking settings. If they are not provided, the Speedway reader will assume defaults for their values.

Table 1 Optional Parameters

Optional Parameter	Definition	Action
-b	Broadcast Address	Defaults to IP address masked with 255
-g	Gateway Address	Defaults to IP address masked with 1
-m	Netmask Address	Defaults to a class C network
-n	Network Address	Defaults to IP address masked with 0

Operationally, Speedway reads the settings provided to the netconf utility via the syntax shown above, computes the remaining settings that were not entered, and uses this information to reconfigure its networking interface. Note that no steps are taken to verify the correctness of these settings with any of the network configuration servers; the user must ensure the validity of the data entered at the command line. Furthermore, in the static configuration mode, the reader will not contact any of the network management services (such as DHCP or DNS) to register its presence. When connecting in this mode, unless steps are taken by the network administrator at the deployment site, the reader can only be contacted via its IP address, and not its host name.

Dynamic Configuration Mode without a Record
The dynamic configuration mode relies on a DHCP server to request the necessary network settings, which can be assigned dynamically when the reader is rebooted or reconfigured with **netconf**. In addition to providing more flexibility than the static mode, the settings provided by the network management authority (the DHCP server) will be assured to be accurate and free of contention.

To invoke dynamic configuration from the **netconf** utility, simply run the following command:

netconf dynamic

In executing the command, the reader issues a DHCP query to request all the necessary network settings. As shown in Table 2, the DHCP query includes a number of fields that identify the reader as a unique device on the network, such that the DHCP server can manage the configurations on a per-device or per-device-type basis, as appropriate.

Table 2 DHCP Query Fields

Field	Description
Vendor Class Identifier	Set to "RFID" to identify the reader as an RFID device
DHCP Client Identifier	Set to the MAC address of the interface to identify the reader as a unique network device
Vendor Encapsulated Options	Set to "Cisco Systems"
User Class	Set to "Default"
Host Name	Set to the current local host name of the reader

The DHCP server responds with all the necessary information that the reader will require to configure its network interface, the most important of which includes:

1. The new IP address, netmask, gateway address, and any other address information required for routing IP traffic through the network.

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2. The active domain name servers on the network, as well as the DHCP lease status.

3. Optionally, the new host name and the domain name. If the host name is specified, then the reader will set its local host name to this value, overriding the value set previously.

Dynamic Configuration Mode with a Record
This network configuration mode, which also relies on the DHCP server for its network settings, is an extension of the *dynamic configuration without a record* mode. It is useful in those cases where the network administrator prefers to create preconfigured records for some or all of the reader devices on the DHCP server. In this mode, rather than the server computing default query field values, it returns the preconfigured data in response to the DHCP request. Note that in this mode, the reader's host name may be overridden with the response returned by the DHCP server.

Configuring Speedway via the Web Interface
If connecting via host name, navigate the browser to http://speedway*n*, where *n* represents the host name suffix (simply concatenate the unit's serial number to the word "speedway" to complete the host name entry). You'll then be directed to the specific Speedway unit's homepage (see Figure 2), which details the host name, IP address, and system statistics information.
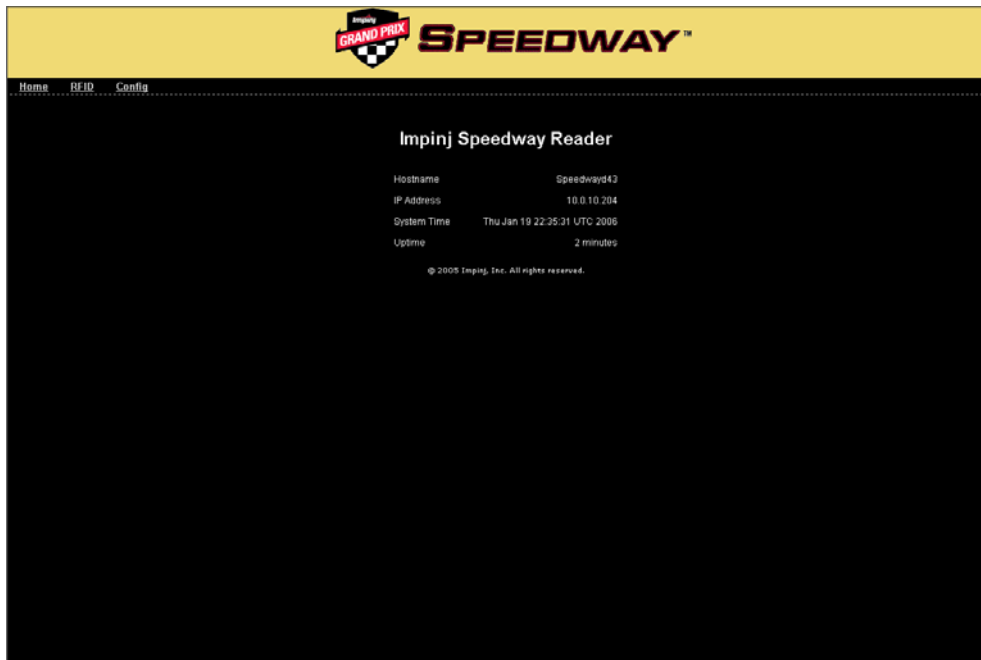

Figure 2 Speedway Reader Homepage

To proceed to the configuration menu, click on the **Config** tab in the screen's navigation bar (will require the same username/password as indicated earlier). The **Upload Configuration to Reader** screen will appear, which provides the option of loading preset configuration settings to the reader. These files are created by establishing the configuration settings on a "golden" reader unit, and then downloading them to a locally stored configuration file. Note, of course, that when this file is uploaded to other readers, fields such as host name must be updated.
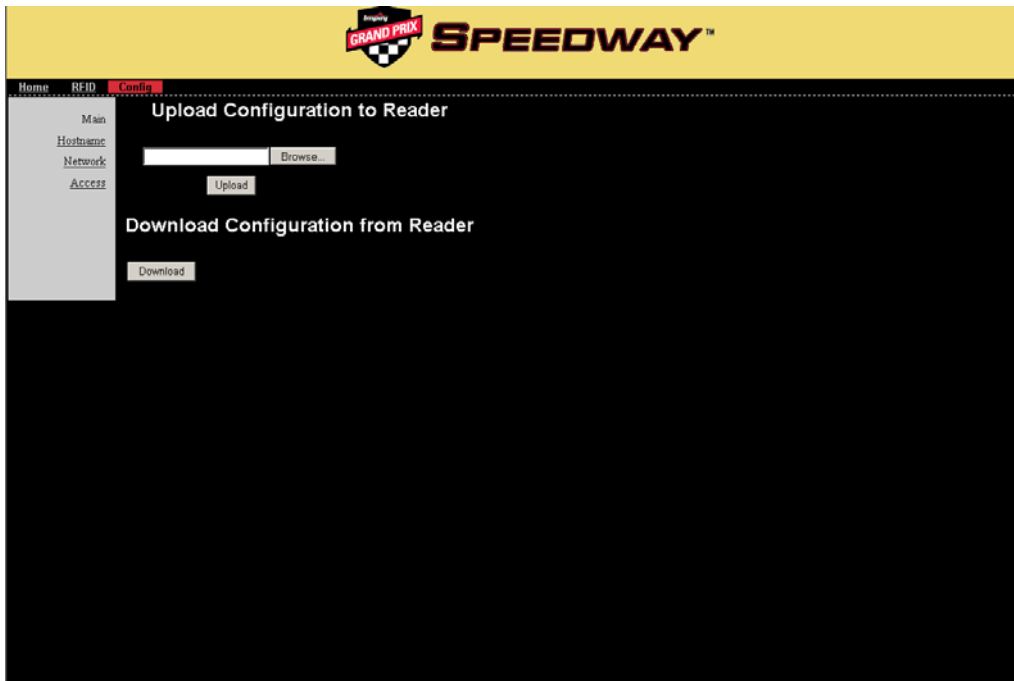
Figure 3 Config Default Page (Upload/Download Configuration)

The three other submenu options in **Config** are **Host name**, **Network**, and **Access**. **Access Configuration** (see Figure 4) provides for changing the password associated with the root command line login.
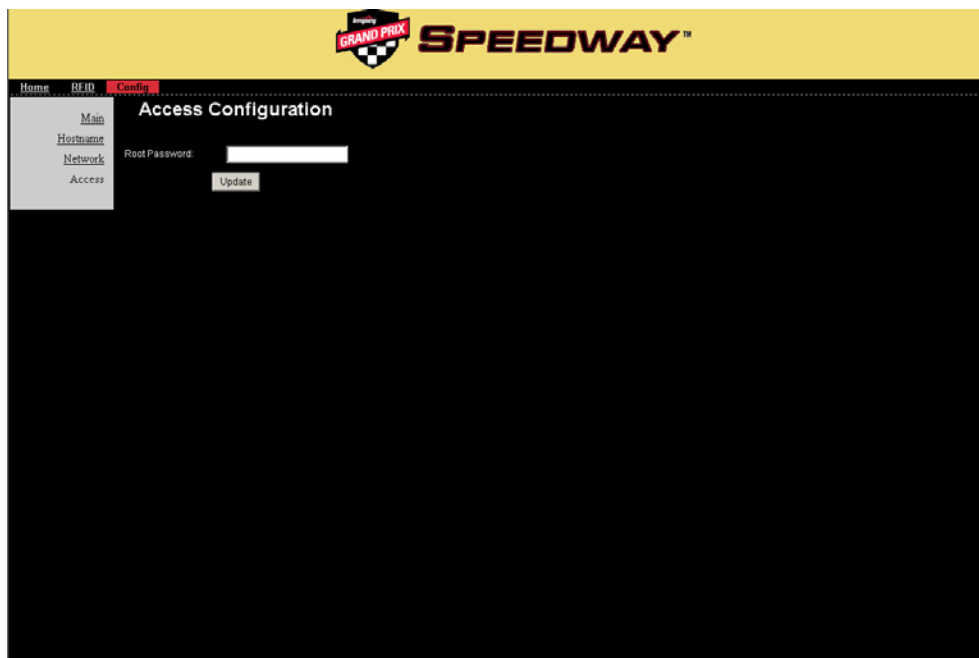

Figure 4 Access Configuration

The host name can be changed under **Host Name Configuration** (Figure 5).

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Figure 5 Host Name Configuration

The network configuration can be established or modified via the **Network** tab (see Figure 6). If you choose **Dynamic**, there's nothing left to do; the host name will be assigned using DHCP over the network. If **Static**, the fixed IP address and its associated parameters are entered in the corresponding fields. These fields have no meaning in the **Dynamic** setting.
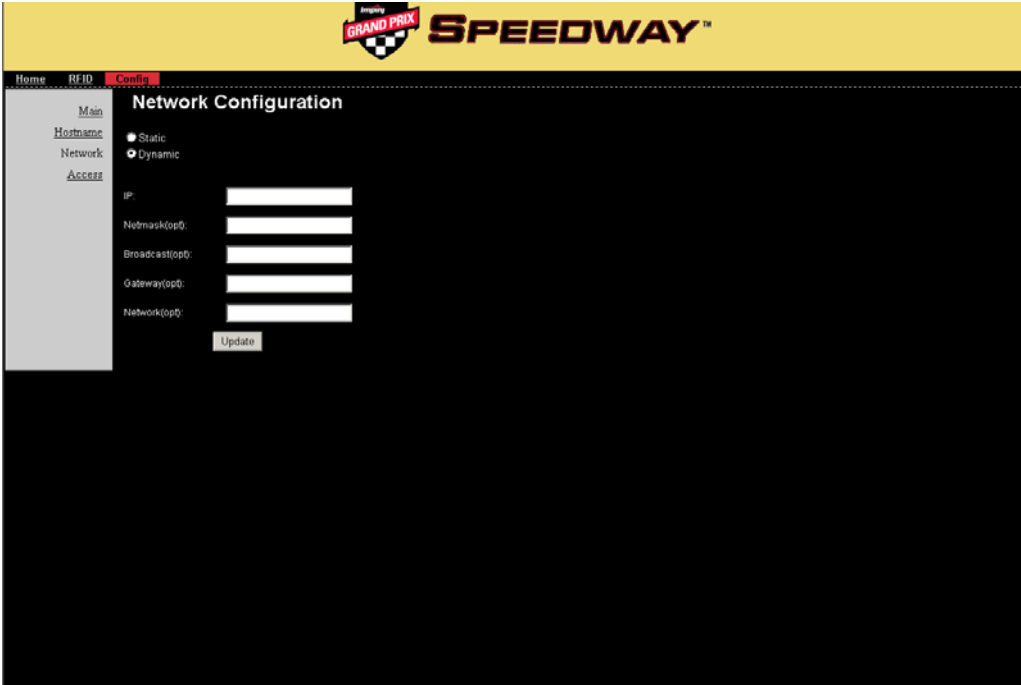

Figure 6 Network Configuration

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Speedway Reader Settings

The Speedway reader applet is a Java program that runs from within a web browser (see Figure 2, Speedway Homepage). Speedway requires Java Runtime Environment (JRE), version 1.4.2 or later. Note that Windows 2000 default is 1.3.1. The latest version of JRE can be downloaded from: **http://java.com/en/download/manual.jsp**

The reader applet is accessed via the RFID menu tab at the top of this page. Clicking this tab will bring up a dialog box prompting the user to enter a login ID and password, the default for which is:

User name: **root**
Password: **impinj**

 The Java program will load and open the **Settings** page (see Figure 6)

The five user-selected fields on the **Settings** page include **Profile**, **Antenna**, **Session**, **Transmit Power**, and **Channel**, each of which are described below.
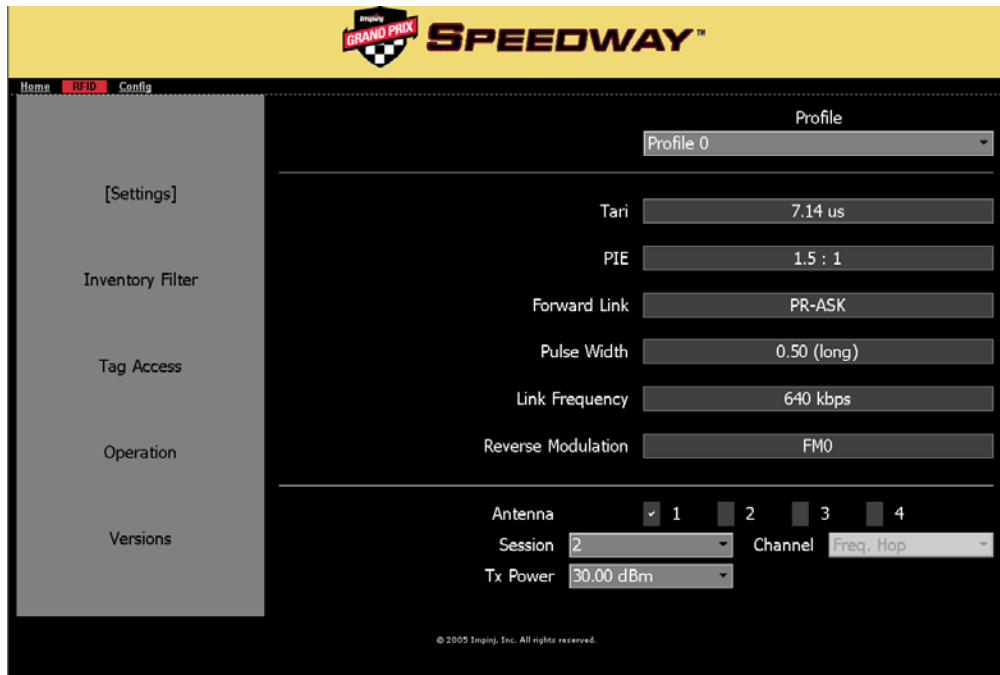

Figure 6 Speedway Reader Settings Page

Profile
The reader mode is established via the Profile pull-down menu, the parameters of which are detailed in Table 2. Each profile (0–3) is a factory preset that configures the reader according to the profiles' respective default settings (Figure 6 shows the settings for Profile 0).

Table 2 Reader Profile Settings

Profile	Tari	PIE	Forward Link	Pulse Width	Link Frequency	Reverse Modulation	Mode
0	7.14	1.5:1	PR-ASK	Long	640 kbps	FM0	High Throughput
1	12.5	1.5:1	PR-ASK	Short	160 kbps	FM0	Medium Throughput
2	25	2:1	PR-ASK	Long	256 kbps	Miller subcarrier, M=4	Dense-Reader 1
3	25	2:1	PR-ASK	Long	256 kbps	Miller, M=8	Dense-Reader 2

Antenna

The Speedway reader supports four (4) independent, bidirectional, full duplex TX/RX ports, which must be cabled to their respective, Impinj-approved antennas prior to power-up. Each antenna port is labeled (ANT1–ANT4) on the Speedway unit, and these designations correspond to the **Antenna** selection buttons that appear on the lower half of the screen. Only those antennas activated by clicking the appropriate button(s) will be operational.

Session

The reader may be assigned to one of four **Session**s (0–3), selectable via this pull-down menu. A function of dense-reader mode, the use of sessions allows as many as four different readers to access the same population of tags through a time-interleaved process. In this mode, a shelf-mounted reader in the midst of a counting operation (assigned to, say, session 1), for example, may be interrupted by another reader entering the field—possibly a handheld reader—to perform its own inventory operation (in session 2, perhaps). Dock door and forklift readers, assigned to sessions 3 and 4 respectively, might also initiate an inventory round. Because Gen 2 tags maintain a separate "inventoried" flag to keep track of each of these various random and independent sessions, they're able to seamlessly resume their participation.

Transmit Power

The reader power setting is selected from the **Tx Power** pull-down menu. Ranging from 15 dBm to a maximum of 30 dBm (in .25 dB increments), measured at the Speedway reader's antenna ports, the maximum setting assumes an antenna with 6 dBi composite gain (inclusive of cabling). An Impinj-approved antenna with higher gain may be used provided the Speedway reader power is reduced so as not to exceed 36 dBm total transmitted power, the maximum allowed by the FCC (see *Connecting the Antennas*).

Channel

The FCC stipulates frequency hopping across the North American spectrum allocated to UHF RFID (902–928 MHz, with hopping occurring between 902.75–927.25 MHz in 500 KHz steps). As such, the Speedway reader does not allow the setting of a static frequency. For North American operation, **Channel** is factory-set and fixed to frequency hop.

Using Filters

The **Inventory Filter** screen (see Figure 7) is the user interface to the *Select* command, which the reader may apply successively to sort a particular tag population based on user-defined criteria, which may include union, intersection, and negation-based tag partitioning (union and intersection operations are performed by issuing successive *Select* commands).

Select commands apply to a single memory bank; the **MemBank** field specifies if the criteria applies to the TID, EPC, or user memory, as follows:

MemBank 00 (0): Reserved
MemBank 01 (1): EPC
MemBank 10 (2): TID
MemBank 11 (3): User

Successive *Selects* may apply to different memory banks. The **Bit Offset** and **Bit Length** fields are used to target a specific portion of the tag memory on which to perform the filtering, while the **Pattern** field contains the comparison bits of interest. As tags are read, the pattern is evaluated against the *Select* criteria, which includes Equal, Not Equal, Greater Than, or Less Than options in the **Comparison** field.

The **Inventory Filter** allows the use of two sets of criteria (defined by primary filter **A** and secondary filter **B**) that may be used separately, jointly, or not at all (the pull-down options include No Filter, A ONLY, A AND B, A OR B). When applied to an inventory round, only those tags that match the S*elect* criteria will be displayed.
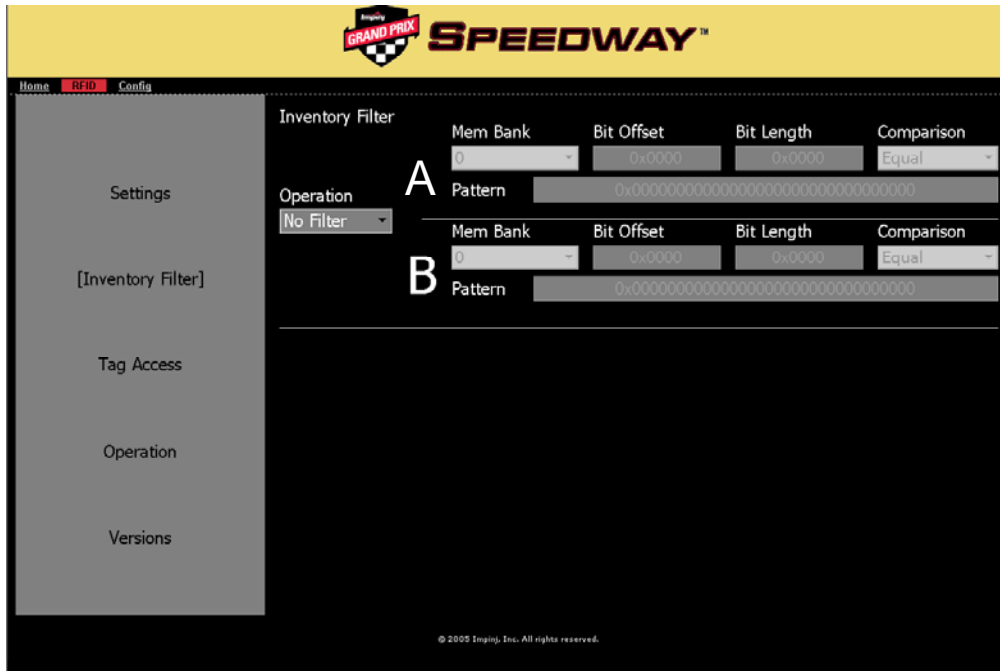
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Figure 7 Inventory Filter

Accessing Tags

After acknowledging a tag, the Speedway reader may choose to access it. The *Access* command set comprises *Req_RN, Read, Write, Kill, Lock, Access, BlockWrite,* and *BlockErase*.

Tag Access (see Figure 8) adds a **Mask** field to the filtering operation, which allows the user to mask individual "don't care" bits or segments of the matching pattern, where "1" identifies a bit of interest and "0" represents a masked bit.

Tag Access differs from the **Inventory Filter** operations in several respects. First, rather than simply continuously inventorying a population of tags, **Tag Access** allows the user to automatically **Halt** the inventory process upon finding a tag of interest (e.g., a tag that meets the **Halt Filter** criteria). At this point, the tag can be automatically read, written, locked, killed, or erased according to the action selected in the **Action** pull-down menu. Furthermore, the action is applied only to the selected **MemBank**, and within it, the desired memory rows (00–07), the rows being made up of 16-bit words. If **Action** calls for a write, the specific bit pattern to be written must be entered (in hex format) in the corresponding field(s) below the selected row number(s). Note that multiple selected rows must be contiguous.

The **Tag Access** view is consistent with the **Operation** view (described below) in that settings applied to one are valid for the other.
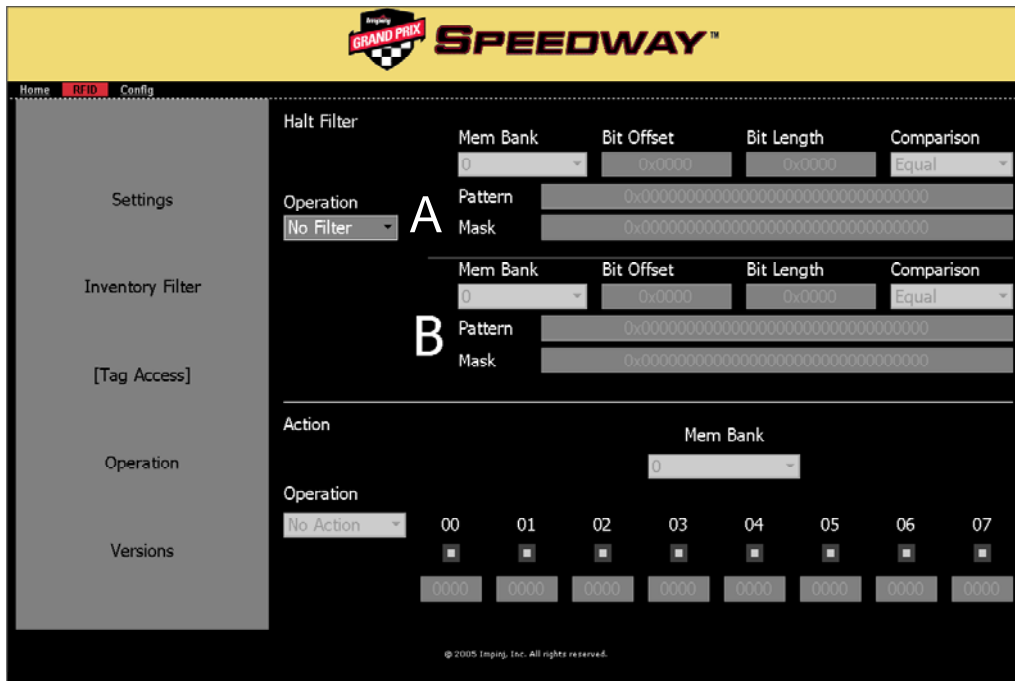
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Figure 8 Tag Access

Operation

If the **Halt Filter** has been activated in **Tag Access**, this status will be indicated in the **Operation** view with the text **Halt Filter** appearing at the top of the screen. Likewise, if the **Inventory Filter** has been activated, the text **Inventory Filter** will also appear. The inventory operation is enabled via the **Start/Stop** toggle button.

Auto Continue

Referring to the set of three buttons in the lower-left portion of the screen, **Auto Continue** directs the reader to continue singulation after a halt condition has been met. Otherwise, if the **Halt Filter** has been set, the reader will stop reading and return control to the user, resuming operation only when the **Continue** button has been clicked by the user. Note also that **Halt** does not require any subsequent action.

Act Once

The **Act Once** button, if enabled, directs the reader to execute the action indicated in the **Tag Access Action** setting (read, write, lock, kill, etc.). If the operation is successful (see **Last Status** column in the primary read window), the reader will continue inventorying or halt operation, depending on the status of the **Auto Continue** setting. Note that if the **Act Once** setting is *not* enabled, and the action indicated is a write, the reader will continuously write the tag over and over in a continuous loop. If, on the other hand, both **Act Once** and **Auto Continue** are enabled, the reader will write the tag once, and then continue the inventory operation, responding in accordance with the **Inventory Filter** settings that have been established.

Read TID

As tags are read, their EPC numbers appear in the primary window of the **Operation** screen. If the **Read TID** button has also been enabled, the logo of the tag silicon manufacturer corresponding to the TID will also be displayed.

Monitoring Inventory Results

The **Start/Stop** button controls singulation of tags within range of the reader. In addition to the EPC and TID (if enabled), the results displayed include **Read Rate** (expressed as tags/sec) and **Running Time** (in hh:mm:ss from last Start). **Total Tags** and **Total Active Tags** report statistics on the total number of tags read as well as the number of tags currently in the reader's field of view. Active tags being read are displayed in white fields, and fade to blue after not being seen by the reader within the last ~10 seconds. To see all tags and their status, simply scroll the screen. Finally, the **Clear** button clears the results of the inventory operation that commenced with **Start**.

To change settings from **Operation** mode:
> a. Stop continuous singulation using the **Start/Stop** button
> b. Return to **Home** screen and configure reader to desired new mode
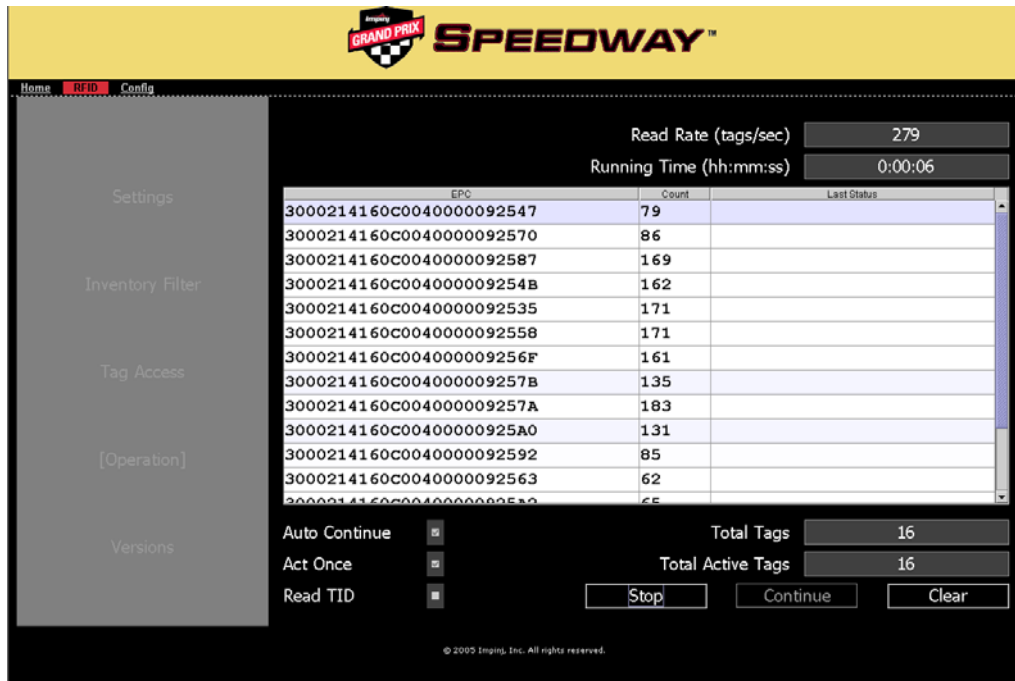> c. Return to **Operation** mode and re-start continuous singulation

Figure 9 Operation

Versions

The **Version** screen (see Figure 10) simply reports the versions of the four primary components of the Speedway reader.
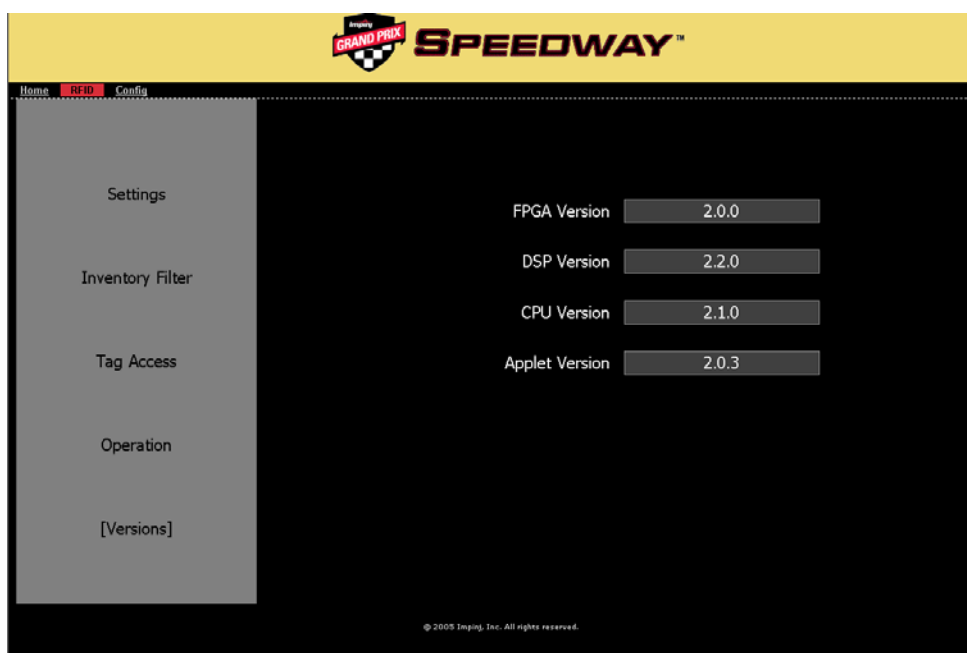
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Figure 10 Versions

Troubleshooting

Refer to Table 3 for resolution of common problems. Technical support is available via phone (206-517-5300) or e-mail (info@impinj.com).

Table 3 Troubleshooting

Problem	Solution
The reader's default page does not load	Most likely the reader operating system is still booting or TCP/IP connectivity has been lost. Retry or "ping" the reader to verify connectivity. If more than 20 seconds have elapsed since power was applied, disconnect and reconnect power, then re-attempt to ping the unit after 30 seconds.
Java applet does not load after selecting "RFID" from default page	Verify that the PC's web browser has Java Runtime Environment (JRE) of version 1.4.2 or later. The latest version of JRE may be installed from: http://java.com/en/download/manual.jsp
"Initializing" or "Calibrating" dialog boxes do not disappear	The reader has likely locked up. Power cycle the reader.
Tags/sec rate varies when configuration settings are changed	This is normal. Currently, the Maximum Throughput mode should have >200 tags/sec, while Dense-Reader or Initialization modes are ~100 tags/sec. Some transmit frequencies will be better than others (no interference or less noise). Best rates will be achieved with 10 to 30 tags within range.
None of the recommend actions fixes the problem	Power cycle the reader.

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