UHF Gen 2 RFID Speedway® Revolution

# Installation and Operations Guide

## Products Covered by this Guide

This guide pertains to readers with the following part numbers:

**Table i: Speedway Reader Part Numbers**

| Reader | Communication Code | Part Number |
|---|---|---|
| Speedway R220 | FCC | IPJ-REV-R220-USA1M1 |
| Speedway R420 | FCC | IPJ-REV-R420-USA1M1 |
| Speedway R220 | ETSI | IPJ-REV-R220-EU11M1 |
| Speedway R420 | ETSI | IPJ-REV-R420-EU11M1 |
| Speedway R220 | Various | IPJ-REV-R220-GX11M1 |
| Speedway R420 | Various | IPJ-REV-R420-GX11M1 |
| Speedway R640 | FCC | IPJR640 |
| Speedway R640 | ETSI | IPJ-REV-R640-EU1M1 |
| Speedway R640 | Various | IPJ-REV-R640-GX11M1 |

## Federal Communications Commission (FCC) Compliance

This equipment was tested and complies 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. If not installed and used in accordance with the instructions, the equipment may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation and cause harmful interference to radio or television reception. To determine if this equipment causes harmful interference to radio or television reception, turn the equipment off and on. You are encouraged to try to correct the interference by one or more of the following:

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

**Caution:** Changes to this product or modifications not expressly approved by the party responsible for compliance could void your 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.

(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 on page 32 that have 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 chosen so that the equivalent isotropically radiated power (EIRP) is not more than that permitted for successful communication. The term "IC" before the radio certification number only signifies that Industry of Canada technical specifications were met.

### CE Marking and European Economic Area (EEA)

RFID devices designed for use throughout the EEA must have a maximum radiated transmit power of 2W ERP in the frequency range of 865.6–867.6 MHz. For other EEA restrictions on RFID device use, please refer to the Impinj Declaration of Conformity (DoC) located at support.impinj.com.

## Before You Begin

**Warning:** Please read this document in its entirety before operating the Speedway Revolution reader, as serious personal injury or equipment damage may result from improper use. Unauthorized opening of the Speedway Revolution reader enclosure voids the warranty. To safeguard personnel, be sure to position all antenna(s) according to the specified requirements for your regulatory region. For details, see "Appendix A: Information Specific to Regions of Operation" on page 33.

# Table of Contents

# Chapter 1: Introduction

## About this Guide

This guide provides detailed instructions for installing, connecting, configuring, operating, upgrading, and troubleshooting the Speedway Revolution or xPortal reader. To minimize and streamline this guide, the content focuses on the installation and operation of a single reader.

### Intended Audience

The intended audience for this guide is anyone installing a Speedway Revolution or xPortal reader. The assumption is however, that the primary users of this guide are systems engineers and IT personnel with experience and basic knowledge of:

- Software development
- Hardware systems integration
- Network connectivity

In addition this guide assumes that the user has a high-level understanding of RFID and RFID systems management as well as a basic familiarity with the EPCglobal Gen 2 specification.

### Other Documents of Interest

This guide is part of a larger documentation set that supports Speedway Revolution. The document set includes the following seven documents:

- ***Speedway Revolution Getting Started Guide***

  Is a one-page guide included with the Speedway Revolution reader. It provides basic information about the hardware as well as instructions for obtaining additional documentation, firmware upgrades and downloads, and other support software.

- ***Impinj LTK Programmer's Guide***

  Provides software engineers guidelines and best practices for working with the Low Level Reader Protocol (LLRP) Toolkit. In addition to this guide, software engineers can access language-specific reference guides and sample applications illustrating the scenarios discussed in the Programmer's Guide.

- ***Octane LLRP***

  Is intended for software engineers and describes the LLRP capabilities supported by Speedway Revolution, which includes Impinj's custom LLRP extensions.

✓ **Note**: Octane is the name for the Speedway Revolution firmware.

- ***Rshell Reference Manual***

  Describes the syntax and command language for the Speedway Revolution Rshell Console.

- ***Octane SNMP Guide***

  Provides monitoring and reference information for working with the SNMP MIBs related to Speedway Revolution (the standard TCP/IP networking MIB (MIB-II) and a subset of the standard EPCglobal RM MIB).
- ***Firmware Upgrade Reference Manual***

  Includes detailed procedures, reference information for upgrading firmware installed on single readers, and procedures for creating a metafile to automate upgrading of multiple readers.
- ***Speedway Revolution Embedded Developer's Guide***

  Provides a high-level description of the Speedway Revolution platform and a high-level view of its architecture for software engineers designing custom application software for the reader.

## Impinj Support Information

Visit the Impinj Support Web site at support.impinj.com for information about obtaining technical assistance. For guidelines on capturing data for analysis by Impinj technical support personnel, see page 31.

# Introduction to Speedway® Revolution


Figure 1.0 Speedway Revolution Reader

Speedway® Revolution is a stationary, small form factor, UHF Gen2 RFID tag reader that provides network connectivity between tag data and enterprise system software. Speedway Revolution is built with the same industry leading quality, high performance, and excellent reliability of Impinj's original Speedway reader. Speedway Revolution offers a variety of new features that increase its application flexibility:

- **Low Power Usage**
  With a low power design, Speedway Revolution is capable of using Power over Ethernet (PoE). Using PoE simplifies deployment and dramatically reduces costs and greenhouse gas emissions of your RFID infrastructure. Using PoE does not compromise Speedway Revolution performance. It delivers the full 30 dBm transmit power (Note – using a AC/DC power module, maximum transmit power is +32.5dBm). Speedway Revolution supports the IEEE standard 802.3af (for PoE).
- **Compact Form Factor**
  The compact size of Speedway Revolution (7.4 x 6.9 x 1.2 in) eases installation in tight spaces and embedded applications.
- **Availability of Two Models**
  Impinj offers two Speedway Revolution models, with different high performance monostatic (transmitter and receiver utilize the same port) antenna port configurations. The model R220 is a two-port configuration and the R420 (shown above) is a four-port configuration.
- **High Performance Features**
  Speedway Revolution utilizes a variety of high performance features making it possible to read more than 1100 tags per second. Features include Autoset, Low Duty Cycle, dynamic antenna switching, inventory search modes that improve tag population management, and receive sensitivity filtering for read-zone confinement.
- **Ease of Use Features**

Speedway Revolution uses industry-standard application interfaces, simplifying its integration with RFID middleware or custom software solutions. In addition, it offers enterprise-class management and monitoring capability.

- **Robust Reader Design**

  Just like its Speedway predecessor, Speedway Revolution uses a single circuit board design that delivers field-proven, enterprise-class quality and reliability.

## Speedway xPortal (IPJR640)

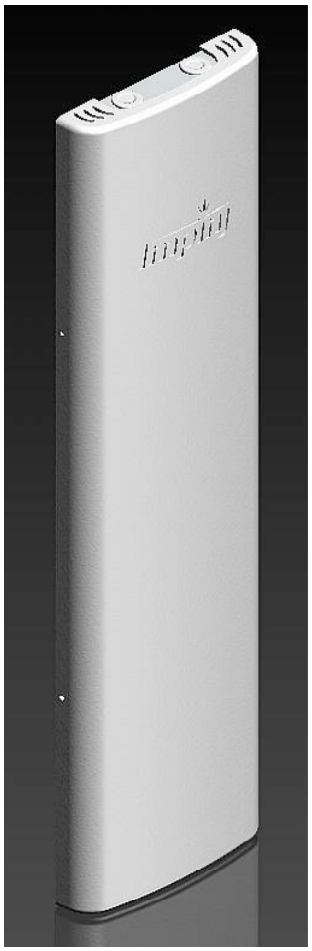


Figure1.2 Speedway xPortal Reader

The newest member of the Speedway family is xPortal integrated portal reader. xPortal incorporates the Speedway Revolution reader with innovative Dual-Linear Phased Array (DLPA) antenna technology in a compact, easy-to-install package. The Speedway xPortal delivers superior performance and unmatched installation versatility for RFID read points at doorways, hallways and general zone coverage in retail, office, hospitality and healthcare environments.

The detail of configuring and using the xPortal is identical to the Speedway R220 or R420 readers, so following sections apply to the xPortal. Appendix C provides the unique installation and cabling hookup instructions for the xPortal on page 46.

The xPortal is an integrated solution with the maximum reader-transmit power set at the factory to comply with country of operation regulations. For usage in the USA or Canada under FCC rules this is 28.5dBm (xPortal's antenna gain is 7.5dBi).

## Requirements for Using Speedway Revolution

This section describes key requirements for operating and interfacing with a Speedway Revolution reader.

### Environmental Requirement

- Operating temperature: -20º C to +50º C (non-condensing)

### Hardware Requirements

- TCP/IP network equipment is required to connect the reader to a PC (Windows, Mac, or Linux), or other network terminal.

- Connecting to the reader console port requires a Cisco type management cable (RJ-45 to DB9) and either a RS-232 serial port or serial to USB adapter on the PC.
- Impinj-approved UHF RFID antenna(s), including associated RF cable(s) with RP-TNC male connector interface.

## Power Requirements

There are two options for powering your Speedway Revolution reader:

1. Power-Over-Ethernet (PoE)
2. An external universal AC to DC power supply.

PoE offers the most efficient power consumption and supports up to +30 dBm. An external universal power supply supports up to +32.5 dBm. Operating above +30dBm requires professional installation. See "Appendix A: Information Specific to Regions of Operation" on page 33 for details.

If you are using a universal power supply module, you must use the Impinj approved part, number IPJ-A2001-000, which supplies +24V DC. Available AC power cords are:

- **IPJ-A2051-USA** (for North America)
- **IPJ-A2051-EU1** (for European Union)
- **IPJ-A2051-BRA** (for Brazil)
- **IPJ-A2051-CHN** (for China)
- **IPJ-A2051-JPN** (for Japan)
- **IPJ-A2051-RSA** (for South Africa)

Ordering the universal power supply and power cords from Impinj is simple and efficient.

## Supported Operating Environments

This section describes the environments in which you can access the Speedway Revolution Rshell console used for configuring, monitoring, and maintaining the reader. The tools you use when accessing the Rshell console depend on how you connect your PC to the reader: serial connection (RS-232) or Ethernet connection (SSH/Telnet). On PCs running Microsoft Windows, you can now use Putty for both types of connections.

**Table 1.1: Supported Operating Environments**

| Interface | Protocol | Recommended Tools | |
|---|---|---|---|
| | | Microsoft Windows | Linus |
| Ethernet | SSH-Port 22<br>Telnet-Port 23 | Putty [1] | SSH or Telnet |
| Serial | RS-232 | Putty (version 0.60 and higher supports serial) | Minicom |

1. http://www.chiark.greenend.org.uk/~sgtatham/putty/

### Supported Communication Protocol

For client control of the reader, Speedway Revolution supports the EPCglobal Low Level Reader Protocol (LLRP) v1.0.1. LLRP is an EPCglobal standard interface allowing communication with the reader, which in turn reads EPCglobal Gen 2 RFID tags.

### Antenna Requirements

Depending on the reader model you are installing, Speedway Revolution is equipped with two (R220) or four (R420) independent, bidirectional, and full duplex TX/RX monostatic antenna ports .

Antenna requirements vary by regulatory region. For details about the requirements in a specific region, see the relevant antenna section in "Appendix A: Information Specific to Regions of Operation" on page 33.

# Chapter 2: Installing and Connecting Speedway Revolution

This chapter provides details about the Speedway Revolution I/O ports and status LEDs, and explains how to install the reader and connect it to your network.

## Speedway Revolution Ports and LEDs

The following graphic illustrates the I/O ports located on the Speedway Revolution reader. This graphic illustrates a Speedway R420, which includes four antenna ports (not visible in this view).

✓ **Note:** Both Speedway R420 and R220 models have the same exterior ports with one exception; the R220 includes two antenna ports where the Speedway R420 includes four antenna ports.

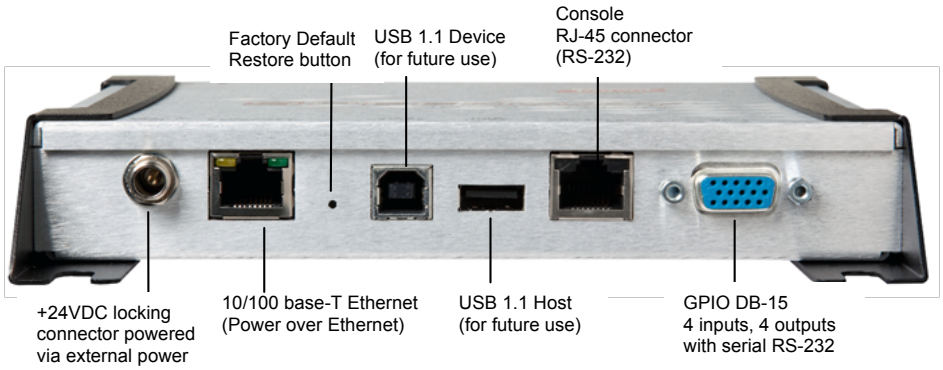



Figure 2.1 Speedway Revolution R420 Port Connections

✓ **Note:** See "Appendix B: GPIO Details" for functional and electrical specifications and details for each pin of the GPIO DB-15 connectors on page 44.

Antenna ports and LED status indicators are located on the back panel of the reader. The Speedway R420 graphic below illustrates their locations:

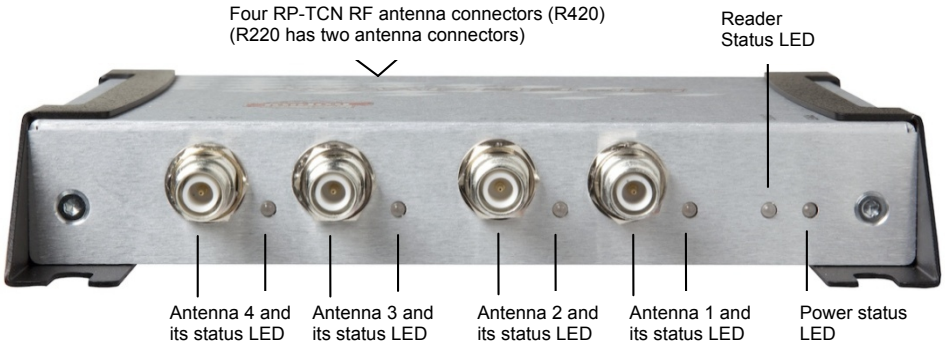



Figure 2.2: Speedway Revolution R420 Antenna Ports and Status LEDs

The following table describes the LED behavior for various reader states:

**Table 2.1: Reader Operations and Associated LED Behavior**

| Reader Operation | | LED | Expected Behavior |
|---|---|---|---|
| **Startup (power on), normal completion** | Power applied, attempting to start boot code | Power | Solid red |
| | | Status | Off |
| | Bootloader calling firmware image | Power | Solid green |
| | | Status | Off |
| | Bootloader completed successfully, reader is ready | Power | Solid green |
| | | Status | Solid green |
| **Startup (reset), normal completion** | Factory Default Restore button pressed | Power | Turns off |
| | | Status | Off |
| | Factory Default Restore button pressed for 3 seconds | Power | Blinks once (red), indicates a configuration default restore will occur |
| **Startup (failure)** | Hardware problems detected, unable to boot | Power | Continuous blinking red |
| | | Status | Off |
| **Upgrade activity** | Upgrading the firmware during boot process | Status | Alternates between red and green |
| **Detection of antenna activity** | Detects no activity on antenna port | Antenna | Off |
| | Detects antenna transmission activity on antenna port | Antenna | Solid green |
| **Inventory activity** | Performing an inventory operation | Status | Blinks orange, blinks faster as tag volume increases |
| **LLRP activity** | Active LLRP connection | Status | Double blink pattern (green) |
| **LLRP activity** | Disconnected operation | Status | Single blink pattern (green) |

## Installing and Connecting the Reader

The primary installation and connection steps for Speedway Revolution are:

1. Position the reader appropriately for your environment. This may or may not involve mounting the reader.
2. Connect the antenna(s) to the appropriate ports on the reader.
3. Connect power to the reader.
4. Connect the reader to the network.
5. Test the reader installation by reading tags.

# Detailed Installation Procedures

This section provides the details for each installing and connecting step.

## Step 1: Position the Speedway Revolution Reader and (optionally) Mount the Reader

Choose the appropriate location for the reader. Ideally you should always keep the unit away from direct sunlight, high humidity, extreme temperatures, and sources of electromagnetic interference. Any combination of these conditions may degrade performance or shorten the life of the unit. Because the Speedway Reader supports Power over Ethernet (PoE), the reader can obtain its electrical power with data via standard cable in an Ethernet network.

If you plan to power the reading using an external universal power supply, confirm there is a standard 120 or 220 VAC outlet nearby. Depending on your environment, you may need to mount the reader to a wall or another object.

### To mount the Speedway Revolution reader:

1. Locate the four mounting slots on the reader, as illustrated below:

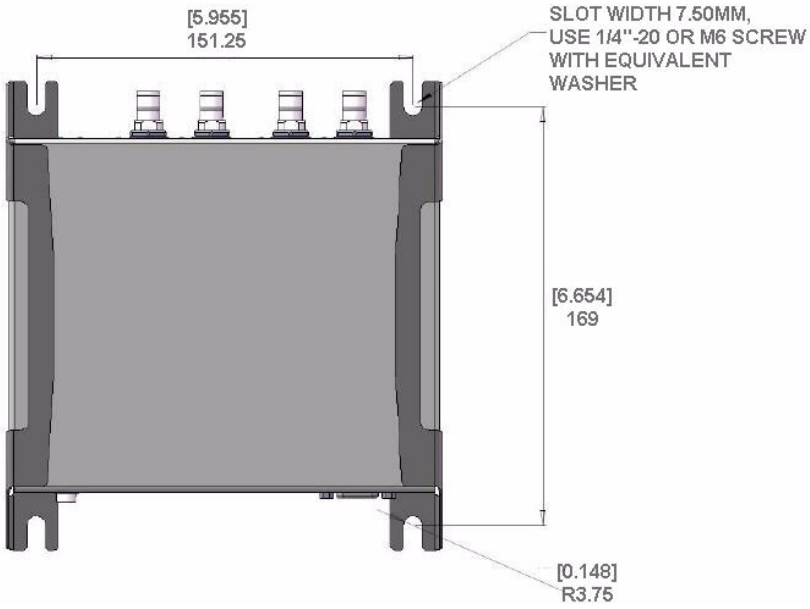



Figure 2.2 Speedway Revolution Mounting Locations

2. Using 1/4" - 20 or M6 screws, secure the unit: mount the reader either horizontally or vertically.

**Caution:** If there is any chance of dust or water exposure, you should mount the reader so that the Ethernet, USB, Console and GPIO ports are facing down to prevent ingress.

## Step 2: Connect the Antenna(s) to the Speedway Revolution Reader

Depending on the Speedway Revolution model you are installing, the reader has either two antenna ports (R220) or four antenna ports (R420). Each port is independent, bidirectional, and full duplex TX/RX (monostatic).

**Warning:** You must use Impinj-approved antennas with Speedway Revolution. See "Appendix A: Information Specific to Regions of Operation" on page 33 for a

detailed list of approved vendors. Using any other antenna may adversely affect performance or damage the reader. Speedway Revolution requires professional installation to correctly set the TX power for the RF cable and antenna selected.

**To connect the antenna(s) to Speedway Revolution:**

1. Position each reader antenna, keeping the following points in mind:
   - Position the antenna(s) to achieve the most effective and efficient tag reads.
   - Position the antenna(s) to maximize operator safety. Personnel should remain at a safe distance at all times. See "Appendix A: Information Specific to Regions of Operation" on page 33 for the specific requirements for your regulatory region.
2. Mount the antenna(s) according to the instructions provided by the antenna manufacturer.
3. Attach the antenna cable(s) to the antenna port(s) on the reader. Choose any port for any antenna.

   Finger-tighten each connection, making sure the connection is secure. The antenna cable is properly tightened when you are no longer able to twist the cable inside the connector.

✓ **Note:** A loose connection negatively impacts the performance of the antenna.

**Caution**: Impinj designed the Speedway Revolution antenna ports to be self-terminating. It is important that you do **not** terminate unused antenna ports. Leave them unconnected.

### Step 3: Power the Reader

You have two choices for powering Speedway Revolution:

- Power over Ethernet (PoE)
- external universal power supply

If your network switch is PoE-enabled, the reader will power on when you connect it to the network.

If you are using an external universal power supply, connect the AC power plug into a suitable 100–240 VAC, 50–60 Hz power outlet.

The boot sequence begins in either case when power is supplied to the reader. This sequence typically completes within 30 seconds. Once the boot sequence finishes, the reader accepts commands, not before. The Power and Status LEDs on the reader alert you the status. See Table 2.1 on page 8 for details.

! **Important:** If a reader is receiving power via PoE and the reader detects that an external universal power supply has been connected, the reader reboots and switches to the external universal power supply source. If, however, the reader is receiving power via an external universal power supply and detects the connection to a PoE-enabled network switch, nothing changes. The reader continues to receive power from the external supply. The external universal power supply always takes precedence over PoE because the universal power supply is capable of higher power if both sources are connected.

### Step 4: Connect Speedway Revolution to the Network

You are now ready to connect the installed Speedway Revolution to your network. You have two options:

- If your network supports DHCP, you can connect the reader directly to your Ethernet network. Once the reader is powered, immediately communicate with it via Telnet (TCP/IP).
- If your network does not support DHCP, you will need to connect a PC directly to the reader using an RS-232 serial connection. Use the reader's Rshell command line interface to configure a static IP address for the reader. Once completed, you will be able to connect the reader to your Ethernet network.

Details for completing each connection option are discussed below. Before proceeding, make note of the reader's factory default network settings:

**Table 2.2: Default Network Settings**

| Settings | Description |
|---|---|
| Hostname | Speedway R-XX-XX-XX where XX-XX-XX is the last three bytes of the reader's MAC address (which is printed on the version label attached to the reader case. |
| DHCP | Enabled. The reader also reports its hostname to the DHCP server. |

**To connect Speedway Revolution to the Ethernet network:**

- Using a standard Ethernet cable, connect the RJ-45 connector on the reader to a LAN drop or network switch. A typical network configuration is illustrated below:

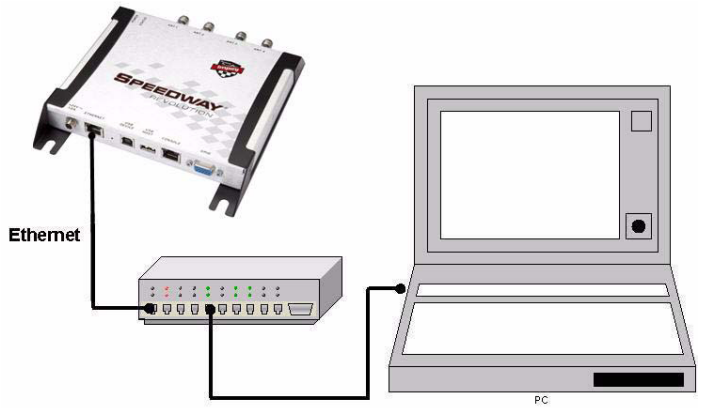



Figure 2.3 Connecting Speedway Revolution to the Ethernet Network

✓ **Note:** If you need to connect a PC directly to the Ethernet port, you can use a standard Ethernet cable. A crossover cable is not necessary.

**To connect Speedway Revolution to your PC over a serial connection:**

1. Confirm you have the latest version of Putty, a free and reliable SSH, Telnet, and serial client. Version 0.60 or higher contains support for serial connections.
2. Using a Cisco style Console cable RJ-45 to DB9, Impinj part number IPJ-A4000-000, connect your PC's valid/active COM port to the serial port on the reader as illustrated below:

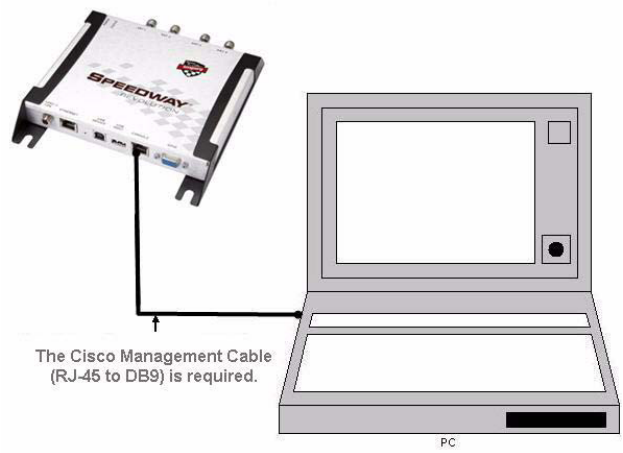



Figure 2.4 Speedway Revolution Serial Connection

3. Power up the reader and wait for the boot sequence to complete. (See "Step 3: Power the Reader" on page 10.)
4. On the PC, run the Putty application and select the **Serial** connection option. Verify that **Serial line to connect to** is set to **COM1** (may be another COM port if you are using a serial to USB adapter)
5. Set **Speed** to **115200**.
6. Set **Flow control** to **None**.

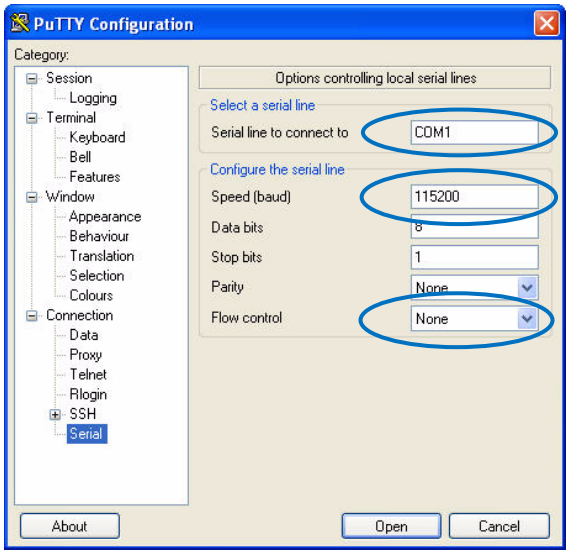



Figure 2.5 Putty Configuration Settings

7. Select **Open**. The Rshell console window opens.
8. Press **Enter**. The Rshell login prompt appears.


Figure 2.6 COM1 Putty Login Prompt

9. Log in with the following default credentials unless you customized them:
   ```
   User Name: root
   Password: impinj
   ```
10. When the Rshell command line prompt appears, begin configuring the network settings for the reader. See "Using Rshell to Configure Network Settings for Speedway Revolution" on page 14 for details.
11. When you have completed configuration of the appropriate network settings, connect the reader to your Ethernet network as described on page 11.

✓ **Note:** If you decide to connect to DHCP after connecting serially, remember to use Rshell to change the IP address on the reader from static to dynamic. See "Using Rshell to Configure Network Settings for Speedway Revolution" on page 15 for details.

### Step 5: Test the Installed Reader

Confirm connections and functionality is correct by reading tags. Using the MultiReader, a Windows PC test application from Impinj, you can quickly verify reader operation by configuring various reader parameters and running simple inventory operations. For details about how to access and use MultiReader, see page 15.

# Chapter 3: Configuring and Monitoring Speedway Revolution

This chapter provides a high-level view of the configuration and monitoring options available for Speedway Revolution.

## Configuring Speedway Revolution

You can think of Speedway Revolution configuration in two categories: configuring the device itself and configuring the reader's RF behavior. This chapter provides the basics for each type of configuration.

### Device Configuration

Rshell is a proprietary command line management interface for configuring and managing network settings, firmware upgrades, and other device-oriented operations. This chapter introduces the Rshell commands for installing and connecting the reader. *Rshell Reference Manua*l provides full details and syntax for all Rshell commands.

✓ **Note:** Rshell is a machine interface and is almost always backward-compatible with previous Speedway Revolution versions. Existing inputs and outputs will never change. When adding new commands, new optional arguments will be added at the end.

! **Important:** The Speedway Revolution version of RShell is **not** 100% compatible with the original Speedway reader.

#### Using Rshell to Configure Network Settings for Speedway Revolution

You can often get up and running with little or no configuration using the default configuration settings in Speedway Revolution. If you are not using DHCP to assign IP addresses, you will need to configure a few of the reader's network settings.

The following procedure outlines the Rshell commands you may need for connecting the reader to your network.

**To configure the reader's network settings:**

1. Open the Rshell console (see page 12 for details).
2. View the reader's current configuration settings by entering the `show network summary` command at the Rshell command prompt:

```
> show network summary
Status='0,Success'
PrimaryInterface='eth0'
ActiveInterface='eth0'
Hostname='SpeedwayR-00-00-B9'
connectionStatus='Connected'
ipAddressMode='Dynamic'
ipAddress='10.0.10.41'
ipMask='255.255.0.0'
gatewayAddress='10.0.0.10'
broadcastAddress='10.0.255.255'
LLAStatus='enabled'
```

3. Configure the appropriate TCP/IP parameters for your environment. The applicable commands are:

   - **Setting Hostname**

     > config network hostname <HOSTNAME>

   - **Setting Static IP Address**

     > config network ip static <IP ADDRESS> <NETMASK> <GATEWAY>

✓ **Note**: The IP address is required; the other parameters are optional. The default value is used if an optional parameter is omitted from the ip command.

   - **Enabling DHCP**

     > config network ip dynamic

   - **Configuring NTP Servers**

     > config network ntp add <NTP SERVER ADDRESS>

4. After successfully configuring all required network settings, connect the reader to the network via the Speedway Revolution Ethernet port.

## RF Configuration

Configuring your reader's RF behavior depends entirely on your implementation approach. You may be using a custom software application, middleware running on a server, or some other approach. MultiReader (see below) is an example of a PC client application. Regardless of the application you're using, the underlying protocol is the same—Low-Level Reader Protocol (LLRP).

LLRP is a standard, asymmetric, binary protocol used for communication between a client application and the reader. LLRP controls the configuration of the antenna transmit power, the receive sensitivity, the operating reader, and more. For details about LLRP, see one or more of the following documents:

- ***LLRP Standard**:* This document provides the specifics of the EPCglobal-ratified LLRP standard. http://www.epcglobalinc.org/standards/llrp/llrp_1_0_1-standard-20070813.pdf
- ***Octane LLRP**:* Provides details of the LLRP capabilities supported by Speedway Revolution. It also describes custom LLRP extensions added by Impinj.
- ***Impinj LTK Programmer's Guide***: Is intended for software engineers and provides guidelines and best practices for working with the LLRP Toolkit. In addition, software engineers can access language-specific reference guides and sample applications illustrating the scenarios discussed in the Programmer's Guide.

### Using MultiReader to Configure and Test Speedway Revolution

Impinj provides a simple, easy-to-use LLRP application for configuring and testing the basic RF behavior of Speedway Revolution. The MultiReader application is available from the Impinj support Web site (support.impinj.com). MultiReader version 6.4.X supports features available with Octane 4.4.X firmware. To use MultiReader, your computer must be running Microsoft Windows XP.

✓ **Note**: MultiReader will install and operate on Windows7, but is not fully tested and supported. We recommend MultiReader for test purposes only.

This section covers connecting to and configuring a reader's RF parameters using MultiReader. It also provides a high-level description of each parameter.

### To configure and test a reader from within MultiReader:

1. Install and launch the MultiReader application. The following screen displays:

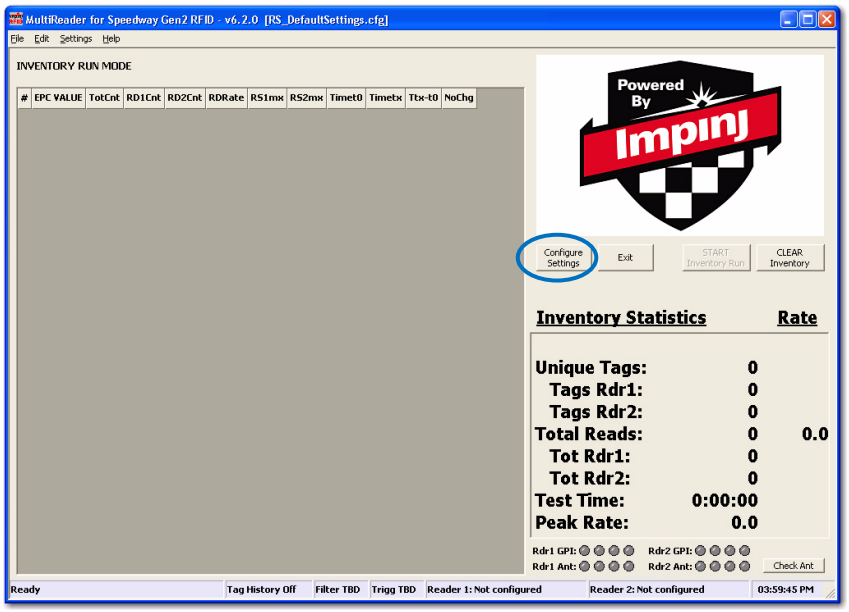



Figure 3.1 MultiReader initial screen

2. Select **Configure Settings**. The **Reader Settings** screen displays:

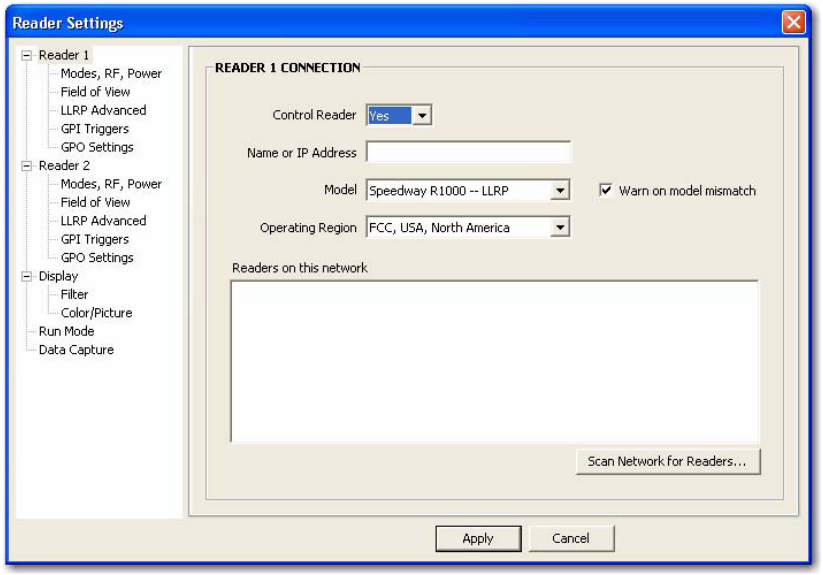



Figure 3.2 Multireader Reader Settings Connection Screen

3. Connect to the reader by doing the following:
4. In **Name or IP Address**, type the reader's IP address or hostname. You can determine the name and the IP address via the Rshell `show network summary` command.

✓ **Note:** The `show network summary` command provides the dynamic values returned by DHCP or LLA if the current configuration is dynamic. The local hostname resolution feature (mDNS) gives the reader a local hostname in addition to an IP address as its network identity. On an isolated network that lacks DNS service but has mDNS enabled, a reader with hostname speedway-00-01-02, for example, may be reached using speedway-00-01-02.local.

5. In **Model**, select the appropriate Speedway Revolution model (either Speedway R220 or Speedway R420). If you want MultiReader to issue a warning if it detects a model other than what is configured, confirm **Warn on the model mismatch** checkbox is selected. (Model mismatch is selected by default.)
6. Configure the key RF parameters described below:
7. Under **Reader 1,** on the left side of the Reader Settings dialog box, select **Modes, RF,** and **Power**. The following screen appears:

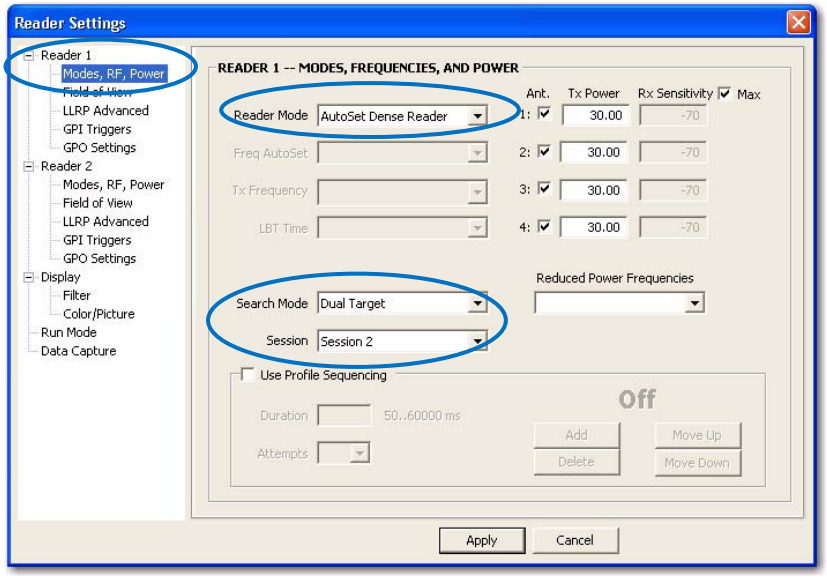



Figure 3.3 Multireader Reader Settings Settings Screen

8. In **Reader Mode**, select **AutoSet Dense Reader**. The Reader Mode specifies the rules to use for communication between the reader and tag. With AutoSet Dense enabled, the reader automatically senses the environment and adjusts its mode accordingly.
9. In **Search Mode**, select **Dual Target**. In **Session**, select **Session 1.** Search Mode and Session work together to control when and how often the reader reads a tag.

   The high-level functional description for the reader is: Each tag contains a flag that is flipped from A to B or from B to A when it is

read. The Session value controls how long the flag retains its value before reverting back to the original tag value. Search Mode controls which flag values the reader reads and, in some cases, what happens to the flag value once the tag is read.

With Dual Target, the reader reads all the tags with A flags, after reading the tags the reader flips each tag to B. When there are no more A tags to read, the reader reads all the B tags, flipping each one to A after it has been read. It continues this process back and forth from A to B and back to A. Session 1 ensures a persistence period that prevents tags from reverting before they have all been read.

10. On the right of the screen is a checkbox for each of the reader's antenna ports. By default, all antennas are enabled. Deselect the checkbox for any port without a connected antenna. Leaving all ports enabled does no harm, but does waste processing time because the reader reads all enabled ports. The reader verifies the presence of an antenna before attempting to activate it.
11. Set the appropriate transmit power, **Tx Power**, and receive sensitivity, **Rx Sensitivity**, for each enabled antenna.

    Transmit power controls the power of the signal leaving the antenna and the signal range. The optimal setting depends on many things:

    - how you are powering the reader
    - cable length connecting the antenna to the reader
    - number of antennas in the area
    - anticipated distance between the antenna and the tags

    Use the default value of 30 dBm for testing purposes.

    Receive sensitivity controls the tag signal threshold below which the tag is ignored by the reader. This parameter is useful in mitigating stray reads. Stray tags often have a weaker signal than the tags to be read. The **Max** checkbox is selected by default, and tells the reader to read all tags, regardless of the tag's signal strength. This is known as its Received Signal Strength Indicator—or RSSI.

    When configuring a specific receive sensitivity, deselect the **Max** checkbox, and then type the value you want for each connected antenna. The maximum sensitivity is -80.

    Remember, you are simply configuring the reader to test your installation. Adjust these settings later when you begin using the reader in a live RFID operation if desired.

12. Select **Apply**. MultiReader displays a progress bar as it connects to the reader. When the connection completes, the following status appears at the bottom of the application:

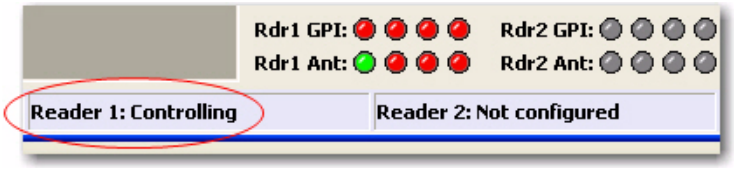
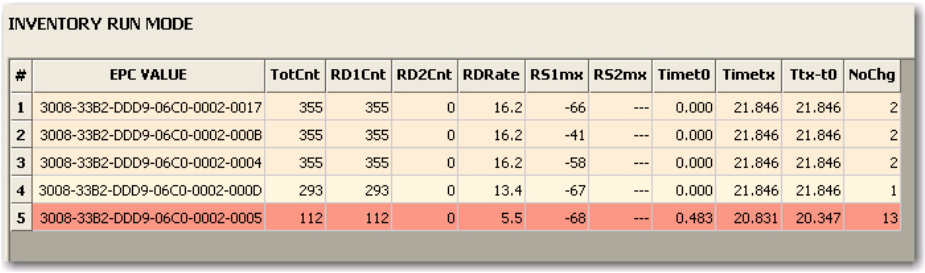



Figure 3.4 Multireader Status Display

13. Test your reader installation. Place one or more tags in the read-zone of one or more of the attached antennas. Select **START Inventory**. Tag reads appear in the large gray area on the left:

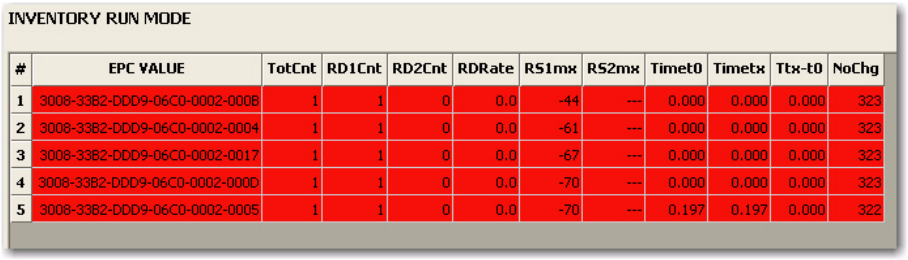


INVENTORY RUN MODE

| # | EPC VALUE | TotCnt | RD1Cnt | RD2Cnt | RDRate | RS1mx | RS2mx | Timet0 | Timetx | Ttx-t0 | NoChg |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3008-33B2-DDD9-06C0-0002-0017 | 355 | 355 | 0 | 16.2 | -66 | --- | 0.000 | 21.846 | 21.846 | 2 |
| 2 | 3008-33B2-DDD9-06C0-0002-000B | 355 | 355 | 0 | 16.2 | -41 | --- | 0.000 | 21.846 | 21.846 | 2 |
| 3 | 3008-33B2-DDD9-06C0-0002-0004 | 355 | 355 | 0 | 16.2 | -58 | --- | 0.000 | 21.846 | 21.846 | 2 |
| 4 | 3008-33B2-DDD9-06C0-0002-000D | 293 | 293 | 0 | 13.4 | -67 | --- | 0.000 | 21.846 | 21.846 | 1 |
| 5 | 3008-33B2-DDD9-06C0-0002-0005 | 112 | 112 | 0 | 5.5 | -68 | --- | 0.483 | 20.831 | 20.347 | 13 |

Figure 3.5 Multireader Tag Inventory Display

In this case, the reader detected five tags. Because the search mode is **Dual Target**, the reader continuously reads the tags, first reading the A flags, and then reading the B flags. Notice in the above image that one of the tag entries is a pinkish color. The tag entry changes to red when a tag is not actively read. For example, if you change the Search Mode to **Single Target with Suppression**, the reader reads each tag only once. All five entries would quickly turn red and stay red as shown below.



INVENTORY RUN MODE

| # | EPC VALUE | TotCnt | RD1Cnt | RD2Cnt | RDRate | RS1mx | RS2mx | Timet0 | Timetx | Ttx-t0 | NoChg |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3008-33B2-DDD9-06C0-0002-000B | 1 | 1 | 0 | 0.0 | -44 | --- | 0.000 | 0.000 | 0.000 | 323 |
| 2 | 3008-33B2-DDD9-06C0-0002-0004 | 1 | 1 | 0 | 0.0 | -61 | --- | 0.000 | 0.000 | 0.000 | 323 |
| 3 | 3008-33B2-DDD9-06C0-0002-0017 | 1 | 1 | 0 | 0.0 | -67 | --- | 0.000 | 0.000 | 0.000 | 323 |
| 4 | 3008-33B2-DDD9-06C0-0002-000D | 1 | 1 | 0 | 0.0 | -70 | --- | 0.000 | 0.000 | 0.000 | 323 |
| 5 | 3008-33B2-DDD9-06C0-0002-0005 | 1 | 1 | 0 | 0.0 | -70 | --- | 0.197 | 0.197 | 0.000 | 322 |

Figure 3.6Multireader Tag Inventory Aging Display

If you see tag data appearing in MultiReader, your reader is most likely installed correctly and the antennas are functioning properly. If you don't see all the tags you placed in the read-zone, try moving the tags to a slightly different location or orientation.

14. Select **STOP Inventory Run** to stop the tag inventory process.

# Monitoring Speedway Revolution

Use Rshell to monitor the reader health and performance when Speedway Revolution is up and running. This section presents the primary Rshell commands for viewing the network and RFID statistics, plus the reader logs. For details about these commands, see the *Rshell Reference Manual*.

Speedway Revolution also supports industry standard SNMP, with MIB2 and EPCglobal Reader Management MIB. For more information, see the *Octane SNMP Guide.*

## Viewing Network Parameters and Statistics

Use the Rshell `show network` command to display networking parameters and statistics. Using this command with the indicated parameters, you can view the following information:

**Table 3.1: Show network Command Parameters**

| Parameter | Displayed Information |
|---|---|
| `dhcp` | Summary of DHCP client configuration |
| `dhcp` | Summary of DNS settings |
| `icmp` | ICMP statistics |
| `ip` | IP statistics |
| `ntp` | Summary of NTP settings |
| `summary` | Summary of network settings |
| `tcp` | TCP statistics |
| `udp` | UDP statistics |

For details about the specific settings and statistics available for each of these parameters, see the *Rshell Reference Manual*.

## Viewing RFID Parameters and Statistics

Use the Rshell `show rfid stat` command to display a reader's RFID parameters and statistics. Using this command with the appropriate parameter, you can view information shown in the Parameter and display table below.

**Table 3.2: Partial listing of show rfid stat parameters**

| Parameter | Displayed Information |
|---|---|
| `ReaderOperationalStatus` | Indicates whether RFID applications are running on the reader |
| `Antenna<n>OperationalStatus` | Indicates if an antenna is physically connected to the reader and operating properly. Note that <n> indicates the antenna port on the reader (1-4). |
| `Antenna<n>EnergizedTime` | Indicates the time that antenna<n> has been powered, in milliseconds. |
| `Antenna<n>UniqueInventory-Count` | Indicates the number of unique tags seen at antenna<n> |
| `Antenna<n>TotalInventory-Count` | Indicates the total inventory count for antenna<n> |
| `Antenna<n>ReadCount` | Indicates the number of tags read at antenna<n> that matched the configured filters. |
| `Antenna<n>FailedReadCount` | Indicates the number of tags where a read was attempted at antenna<n> because the tag matched the configured filter, but the read failed. |

Table 3.2 shows a sample of the available RFID statistics. For the full list as well as syntax details, see the *Rshell Reference Manual*.

✓ **Note:** View Statistics on the LLRP interface between the reader and a client by entering the `show rfid llrp` stat command. The *Rshell Reference Manual* provides details.

### Configuring and Viewing Speedway Revolution Logs

Speedway Revolution uses the standard Syslog protocol to forward its logged events to a remote Syslog server. The reader stores the logged events in its file system, accumulating and persisting this information across reboots. Logs are classified into three categories: Management, RFID, and System.

All logged events have an associated severity level. There are eight possible levels listed in decreasing order from most severe to least severe:

- Emergency
- Alert
- Critical
- Error
- Warning
- Notice
- Info
- Debug

Configure the log levels you want to display. The reader then retains only the events with a severity greater than or equal to the configured level. For example, if you choose a logging level of Warning, then the logs will contain the following levels: Warning, Error, Critical, Alert, and Emergency.

✓ **Note:** Regardless of the configured log level, the reader retains all Error level logs and higher in an independent error log.

Use the Rshell `config logging` command to configure options for the storage and forwarding of logged events. Use the `show logging` command to display the logging configuration as well as the actual logged information in text form. For details about these commands, see the *Rshell Reference Manual*.

### Viewing the State of the Speedway Revolution Device

To display information about the current state of the reader itself, use the Rshell `show system` command. Using this command allows viewing the following statistics:

- A summary of system information—`show system summary`
- Platform memory usage and available application space—`show system cpu`
- Generic platform statistics—`show system platform`

For more details about the `show system` command, see the *Rshell Reference Manual*.

# Chapter 4: Upgrading the Speedway Revolution Firmware

Speedway Revolution contains firmware known as Octane. The current version of Octane is 4.4. This chapter details manually upgrading a single reader.

In addition to supporting upgrade procedures, Speedway Revolution also provides methods for reverting firmware to a previous valid image and restoring firmware to factory default settings. The procedure for reverting to the previous valid image is explained in this chapter, while returning to factory defaults is explained in Chapter 5.

## A Brief Overview of the Speedway Revolution Firmware

To minimize downtime and maximize the robust handling of possible upgrade failures, Speedway Revolution contains dual images of its firmware. When requesting a firmware image upgrade, the reader continues to operate using the primary image. In the background, Speedway Revolution upgrades the secondary image. When the upgrade completes, the reader reboots to the newly upgraded image. Speedway Revolution retains the previous firmware version in case there are problems with the upgrade.

There are three individual partitions within each firmware image that logically organize the system software. Although you do not need a full understanding of this architecture to perform a simple manual upgrade, it is a good idea to be familiar with its structure at a high level. For a more in-depth discussion of the firmware and how firmware is organized, see the *Embedded Developer's Guide.*

The three partitions in firmware are:

- **System Operating Partition (SOP)**—The SOP is the primary system partition of the Speedway Revolution reader. It contains the Linux kernel, FPGA firmware, RFID management software, reader management software (Rshell), logging management software, firmware upgrade control, system watchdog software, and the factory default data.
- **System Persistent Partition (SPP)**—Files in this partition are automatically generated and maintained by the software running on the reader. It contains the reader configuration (network settings, LLRP configuration, log settings, and so on), reader logs, and debug information used by Impinj engineers.
- **Custom Application Partition (CAP)**—CAP partition contains custom application software, other items required by the custom application (extra libraries or tools, and configuration files), plus custom application logs.

## Upgrading the Firmware

Speedway Revolution provides three methods for upgrading:

- using Rshell, command line interface
- copying the firmware to a USB memory drive and plugging into the reader's host port
- via the web interface

**Upgrading the Firmware using Rshell:**

1. Obtain the firmware upgrade file from the Impinj support Web site, support.impinj.com. The upgrade file extension is `.upg`. (for example octane_4_4_0.upg).
2. Place the upgrade file on a server (http, tftp, or ftp) accessible by the reader you are upgrading.
3. Using the Putty application, connect the reader using telnet, SSH or serial and log in.
4. From the Rshell command prompt, issue the following command:

   ```
   >config image upgrade <URI>
   ```

   Where <URI> is the server location and name of the upgrade file.

   For example:

   ```
   >config image upgrade http://usacorp/rfid/reader/image/
   octane_4_4_0.upg
   >config image upgrade ftp://anonymous:abc@myserver/
   ftpdirecotry/octane_4_4_0.upg.upg
   >tftp://server/octane_4_4_0.upg
   ```

5. After starting the upgrade, view the upgrade status at any time by issuing the following command:

   ```
   >show image summary
   ```

6. This command provides a display of the current upgrade status, the last operation, the status of the last operation, and information about the primary and secondary images. Reissue the `show image summary` command if you want to track the upgrade status. Some status values you may see are:

   ```
   WaitingForImageFileTransfer
   WaitingForCommitImage
   WaitingToActivateImmediate
   ```

   The upgrade is complete when the UpgradeStatus parameter value is

   `Ready`.

   The LastOperation parameter should be `WaitingToActivateImmediate` and the LastOperationStatus should be `WaitingForManualReboot`.
7. Reboot the reader by issuing the following command:

   ```
   >reboot
   ```

   Speedway Revolution reboot process displays messages in the Rshell console as it goes through each stage of the process. The reboot completes then the reader login prompt appears on the console. The reader status light displays solid green. LED reader reboot behavior details are provided on page 8.

### Upgrading the Firmware with a USB Drive

Speedway Revolution running Octane 4.4 and later supports upgrading the firmware using a USB drive.

First, obtain the firmware upgrade file from the Impinj support Web site, support.impinj.com. The upgrade file extension is `.upg`. (for example octane_4_4_0.upg).

### Preparing the USB Drive for upgrade

1. Insert a USB drive into your computer.
2. Create an *Impinj* directory in the root of the USB drive along with the subdirectories revolution, upgrade, and images. The names of the directory are case sensitive and must all be lower case.
3. Copy the desired firmware upgrade ".upg" file into the "\impinj\revolution\upgrade\images\" directory. If multiple ".upg" files exist in the images directory, the reader will use the file modified most recently.
4. Remove the USB drive from your computer.

### Using the USB Drive

1. Confirm that the reader is ready for upgrade with both the Power and Status LEDs illuminated.
2. Insert the USB drive into the "USB Host" port on the reader.
3. Within 5-10 seconds, the reader will begin upgrading the reader and the Power LED will blink amber. If the Power LED remains solid green, the reader likely cannot locate the images directory and ".upg" file on the USB drive.
4. When the upgrade process completes (20-60 seconds), the Power LED will change to solid green.
5. Remove the USB drive from the "USB Host" port and reboot the reader.

During the upgrade process, the reader will attempt to append information to a "status.log" file in the "Impinj/revolution/upgrade" directory. The "status.log" file is intended to provide an audit trail for the upgrade of one or more readers.

If the firmware upgrade process fails the Power LED will blink red. Remove the USB drive reboot the reader and check the "status.log" file for the reason of the failure.

### Upgrading the Firmware through the Impinj Management Web UI

Speedway Revolution running Octane 4.4 and later supports upgrading the firmware using the Impinj Management Web UI.

1. Connect to the reader using a web browser http://<reader name or IP address>.

   Examples: http://speedwayr-10-00-DD or http://10.0.10.44.
2. Log in to the reader;

   user name: root

   password: Impinj

3. Click the "Browse" button and select the firmware upgrade ".upg" file.
4. Click the "Upgrade" button.

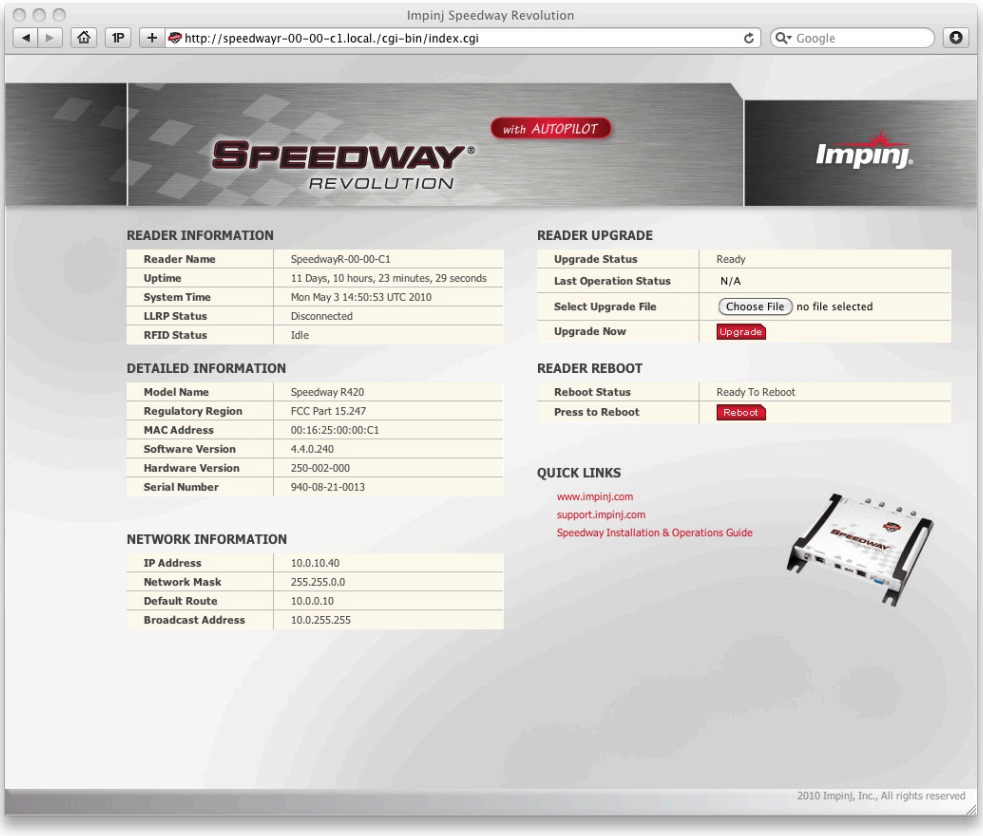



Figure 4.1 Speedway Revolution Management Web Page

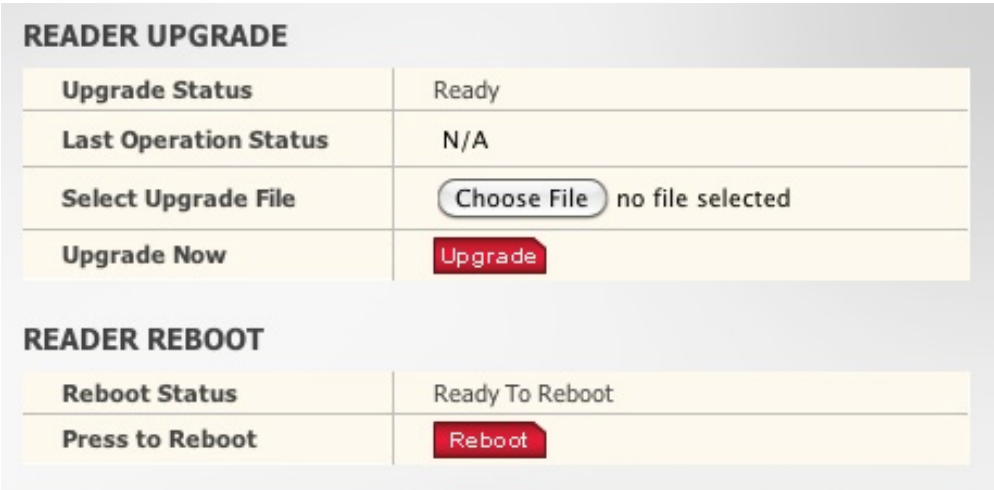



Figure 4.2 Close-up of Reader Upgrade and Reboot Section of Management Web Page

### To fall back to the previous image

1. To revert to the pre-upgrade image, enter the following command from the Rshell prompt:

   ```
   config image fallback
   ```

   When the command completes successfully, the reader automatically reboots and returns to the login prompt.

2. Log in to the reader. The pre-upgrade image is now running.

✓ **Note:** If there is no valid previous image, the response to the `config image fallback` command is Status=`8, Permission-Denied`.

# Chapter 5: Troubleshooting

If you experience a problem with Speedway Revolution, this brief chapter presents a few suggestions to correct the issue.

## Returning to the Factory Default Configuration

If you are experiencing a problem with the reader and are having difficulty pinpointing the cause, it is useful to return the reader to a known state. We recommend resetting to the factory default configuration. Then try your reader again.

**Important:** Factory Default Configuration Restore returns the reader configuration to its default state. It leaves any custom applications installed in the CAP intact. To restore the reader to its default state **and** remove any CAP contents, use Factory Default Restore. See the **Warning** on page 28.

There are two ways to return Speedway Revolution to its factory default configuration: issuing an Rshell command or pushing the Factory Default Reset (FDR) button on the device.

### To use Rshell to return the reader to its factory default configuration and leaving CAP intact:

1. At the Rshell prompt, enter the following command:

   ```
   config image default
   ```

   When the command completes successfully, the reader automatically reboots and returns to the login prompt.
2. Log in to the reader. The reader is now running with the factory default configuration. CAP applications are intact.

### To use the FDR button on the reader to restore to its factory default configuration:

1. Using an object with a sharp tip, a paper clip or probe, press and hold the FDR button on the back while the reader power is on.
2. Continue holding the FDR button. Wait for 3 seconds after the Power LED turns off.
3. Release the FDR button when the LED blinks red once. The reader will boot up normally in the factory default configuration.

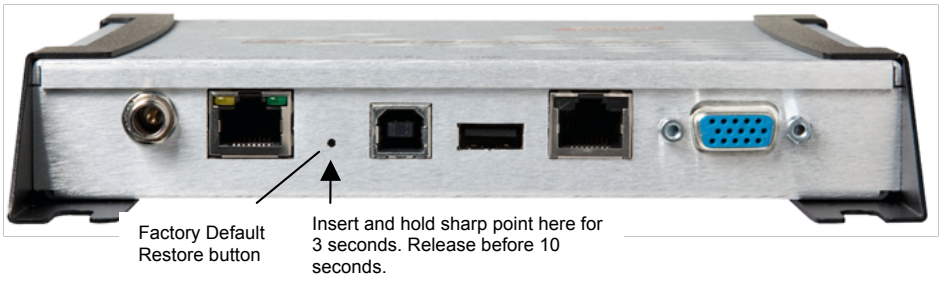



Figure 5.1 Factory default reset button

**Warning:** Pressing the FDR button for longer than 3 seconds can cause a factory default restore to occur. The factory default restore removes the reader's custom

application partition (CAP) if one exists. The reader returns to the original, factory shipped state. It is important to avoid accidentally removing the CAP. There may be situations where CAP removal is necessary.

The following table lists the factory default configuration values:

**Table 5.1: Factory Default Configuration Values**

| Parameter | Default Value |
|---|---|
| User | root |
| Password | impinj |
| Upgrade Retrieve Mode | Manual |
| Logging | No syslog servers |
| Management Logging Level | Error |
| RFID Logging Level | Error |
| System Logging Level | Error |
| Network Mode | Dynamic (DHCP) |
| DHCP Send Hostname | On |
| Hostname | speedway-xx-xx-xx (where xx-xx-xx are the last three digits of the MAC address) |
| Static DNS Servers | None |
| Static NTP Servers | None |
| LLRP Inbound Port | 5084 |
| LLRP Inbound Service | Enabled |
| LLRP Outbound Service | Enabled |
| LLRP Outbound Servers | None |
| LLRP Outbound Retry Secs | 5 |
| LLRP Outbound Timeout Secs | 2 |

# Submitting Diagnostic Data for Analysis by Impinj Technical Support

If Speedway Revolution is exhibiting RF behavior differing from what you expect and you are unable to determine the cause, you may want to submit relevant data for analysis by Impinj Technical Support. Using the Impinj MultiReader application, you can easily capture data relating to the problem scenario. By creating and providing a Reader Diagnostic Data file, Impinj's Technical Support team can troubleshoot your issue.

### To capture data to a Reader Diagnostic Data file:

1. Open MultiReader and connect to the appropriate Speedway Revolution reader. See page 15 for details.
2. Select **Configure Settings** to open the **Reader Settings** screen.
3. Verify that you are viewing the connection settings for Reader 1. If you are not, select **Reader 1** in the menu on the left.
4. In **Control Reader**, select **No**.

   This setting value tells MultiReader that you do not want the MultiReader configuration controlling the reader. Changing this value is important because you most likely want to capture data for a reader operation that is being controlled by your application.

   If, however, you want to capture an RF scenario that is controlled by MultiReader, set **Control Reader** to **Yes**.
5. In the menu on the left, select **Data Capture**. The following screen appears:

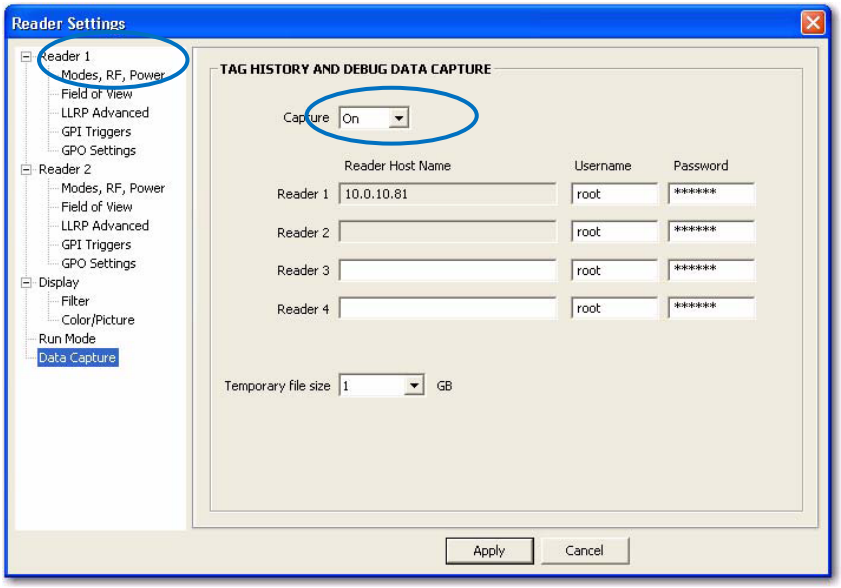



Figure 5.2 Reader Settings, Tag History & Debug Data Capture

Reader 1 is already populated with the IP address. Login parameters are also populated. If these values are incorrect, change them here. You can capture data for up to four readers simultaneously. In this example, we are capturing data one reader.

6. Confirm that **Capture** is set to **On**.

7. Select **Apply**.
   MultiReader connects to the reader and begins "listening" for any RF activity. The reader captures data surrounding any RF activity it detects.
8. Perform the RF activity to submit for analysis.
9. Select **File** in the upper left corner of the application.
   This completes the capture activity.
10. Select **Save Debug Data...**. A browse window opens.
11. Enter a file name and save the file in the desired location.
12. Send the `.rdd` file containing binary data to Impinj Technical Support.
    Visit the Impinj support Web site, support.impinj.com., for submission details or talk with your Impinj representative.

✓ **Note:** Another option is to create a network trace using Wireshark, a free protocol analyzer download from the Internet.

# Appendix A: Information Specific to Regions of Operation

Speedway Revolution is designed to work in various regulatory regions. This appendix contains frequency ranges and antenna requirements specific to each supported region.

**Important:** Each reader is locked to operate at region-specific frequencies only allowed by your local country regulations. Find your region-specific frequencies in this appendix.

# Operation in North America

## Frequency Plan

The FCC specifies 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). The frequency plan is further explained in the table below:

**Table A.1: Frequency Plan for North America**

| Transmit Channel Number | Center Frequency (MHz) |
|---|---|
| 1 | 902.75 |
| 2 | 903.25 |
| 3 | 903.75 |
| 4 | 904.25 |
| … | … |
| 49 | 926.75 |
| 50 | 927.25 |

## Antenna Requirements

### Positioning

Position the antenna's surface at least 25 centimeters away from personnel working in the area. This is an FCC positioning requirement. For more details, see the following FCC bulletins:

- FCC OET Bulletin 65: *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields*
- FCC OET Bulletin 56: *Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields*

### Installation

Speedway Revolution is capable of up to +32.5 dBm conducted power on the housing RF connector and requires professional installation.

### Power

Speedway Revolution may only be operated with Impinj-approved antennas and can radiate no more than 36 dBm EIRP per FCC Part 15.247 regulations. The Speedway Revolution output power may be increased to provide the maximum allowable EIRP subject to a maximum conducted power allowance of 30 dBm at the antenna connector. The maximum allowable output power of the reader can be set to satisfy both the conductor and radiated maximum criteria. The expression for the maximum reader power setting is:

Maximum power setting (in dBM) = the Smaller of:

(36 – Composite Antenna Gain (in dBM)) OR (30 + Cable Loss (in dBM),

where the composite antenna gain comprises the maximum linear antenna gain in dBi minus any cable loss between the reader and antenna in dB. Approved antenna vendors, model numbers, and associated gain are listed in the next section.

✓ **Note**: The composite antenna gain comprises the maximum linear antenna gain in dBi minus any cable loss between the reader and antenna in dB. Approved antenna vendors, model numbers, and associated gain are listed in the next section.

### Approved Antennas

- Laird Technologies model number S9028PCL/R (left- or right-hand CP), with integrated 8 foot pigtail to RP-TNC male connector; 6 dBi composite gain
- Impinj model number IPJ-A0301-USA (Mini-Guardrail) with SMA female connector; -15 dBi gain
- Impinj model number IPJ-A0310-USA (Threshold-T Antenna) with 12 inch integrated pigtail to BNC male connector, 6 dBi composite gain.
- Impinj model number IPJ-A0400-USA, CSL CS-777-2 (Brickyard) with 7 foot integrated pigtail to RP-TNC male connector; 2 dBi composite gain
- Impinj model number IPJ-A0401-USA or IPJ-A0402-USA (both Guardwall) with 6 foot integrated pigtail to RP-TNC male connector; 6 dBi composite gain
- MA/COM MAAN-000246-FL1 integrated RFID floor-mounted stand (multiple configurations available, 2 or 4 antennas left-hand and right-hand CP) with 8 foot integrated pigtail to RP-TNC male connector; 6 dBi composite gain
- MA/COM MAAN-000246-WL1 integrated RFID wall-mounted stand (multiple configurations available, 2 antennas left-hand and right-hand CP) with 8 foot integrated pigtail to RP-TNC male connector; 6 dBi composite gain
- MTI MT-262006/TLH (left-hand CP) or MT-262006/TRH (right-hand CP) with RPTNC female connector (antennas available in IP54 or IP67 ratings); 6 dBi gain
- MTI MT-262013/NLH (left-hand CP) or MT-262013/NRH (right-hand CP) with Ntype female connector (antennas available in IP54 or IP67 ratings); 4.5 dBi gain

- MTI MT-262013/TLH (left-hand CP) or MT-262013/TRH (right-hand CP) with RPTNC female connector (antennas available in IP54 or IP67 ratings); 4.5 dBi gain
- Sensormatic Electronics Corp. model number IDANT20TNA25 with 25 foot Belden 7806A RG-58 coaxial cable (0.1 dB per foot loss) to RP-TNC male connector; 5.5 dBi composite gain
- Sensormatic Electronics Corp. model number IDANT10CNA25 with 25 foot Belden 7806A coaxial cable (0.1 dB per foot loss) to RP-TNC male connector; 3.5 dBi composite gain
- Sensormatic Electronics Corp. model number IDANT10CNA25 with 6 foot Belden 7806A coaxial cable (0.1 dB per foot loss) to RP-TNC male connector; 5.4 dBi composite gain

**Warning:** The use of any antenna not listed above may damage the reader or adversely affect performance.

# Operation in European Union

## Frequency Plan

For European operation, the Speedway Revolution readers support the frequency plan listed in Table A.2 and are compliant with the ratified ETSI EN 302 208 specification v.1.2.1. This specification states that no listen-before-talk is performed, the maximum continuous transmit time on a channel is four seconds, and the reader enforces the 100 ms off time before reusing the same channel.

**Table A.2: Frequency Plan for European Union**

| Transmit Channel Number | Center Frequency (MHz) |
|---|---|
| 4 | 865.7 |
| 7 | 866.3 |
| 10 | 866.9 |
| 13 | 867.5 |

## Antenna Requirements

### Power

European regulations allow a maximum radiated power of 33 dBm ERP (Effective Radiated Power) for high power RFID systems. The maximum Speedway Revolution output power is determined by the following equation:

Maximum power setting (in dBm) = 33 – Antenna Gain (in dBd) + Cable loss (in dB)

For example, for an application with an antenna gain of 6 dBd and cable loss of 2 dB, the reader output power can be set no higher than 33-6+2 = 29 dBm. The maximum transmit power of Speedway Revolution is 31.5dBm measured at the RF antenna port.

✓ **Note:** It is important to apply the antenna gain expressed in dBd (dB with respect to a dipole), which is equivalent to the isotropic antenna gain (in dBi) minus 2.15 dB. Additionally, the antenna gain used to set the output power must be the maximum linear gain of the applicable antenna. Approved antenna vendors, model numbers, and associated gain are listed in the next section.

### Approved Antennas

- Laird Technologies Model Number S8658PCL/R (left- or right-hand CP) with integrated pigtail to RP-TNC male connector; 3.85 dBd gain
- Impinj Model Number IPJ-A0400-EU1, CSL CS-777-1 (Brickyard) with 7 foot integrated pigtail to RP-TNC male connector; 0 dBd composite gain
- MTI MT-242032/NLH (left-hand CP) or MT-242032/NRH (right-hand CP) with Ntype female connector (antennas available in IP54 or IP67 ratings); 1.85 dBd gain
- Sensormatic Electronics Corp. Model number IDANT10CEU25 (left-hand CP only) with 6 foot Belden 7806A coaxial cable (0.1 dB per foot loss) to RP-TNC male connector; 3.25 dBd composite gain

**Warning:** The use of any antenna not listed above may damage the reader or adversely affect performance.

## Operation in Other Global Regions

For operation and use in the Rest of the World (ROW), the IPJ-REV-R420-GX1 (GX1 stands for Global1) and IPJ-REV-R220-GX1 models are available. Please contact Impinj to learn which countries and regions are currently certified. Your local Value Added Reseller (VAR) will provide the GX1 reader to you with the country (region) of operation locked.

### Installation

Because Speedway Revolution is capable of up to +32.5 dBm conducted power on the housing RF connector, **professional installation is required**.

### Operation in Israel, Malaysia, Singapore, and Vietnam

Regulations in these countries allow a maximum radiated power of 33 dBm ERP (Effective Radiated Power) for high power RFID systems. The maximum Speedway Revolution output power is determined by the following equation:

Maximum power setting (in dBm) = 33 – Antenna Gain (in dBd) + Cable loss (in dB)

For example, for an application with an antenna gain of 6 dBd and cable loss of 2 dB, the reader output power can be set no higher than 33-6+2 = 29 dBm. The maximum transmit power of Speedway Revolution is 32.5dBm measured at the RF antenna port.

✓ **Note:** It is important to apply the antenna gain expressed in dBd (dB with respect to a dipole), which is equivalent to the isotropic antenna gain (in dBi) minus 2.15 dB. The antenna gain used to set the output power must be the the maximum linear gain of the applicable antenna. Approved antenna vendors, model numbers, and associated gain are listed in the following section.

### Operation in Australia, Brazil, Hong Kong, Taiwan, Thailand, and Uruguay

Regulations in Australia, Brazil, Hong Kong, Taiwan, Thailand, and Uruguay allow maximum radiated power of 36 dBm EIRP. The Speedway Revolution output power may be increased to provide the maximum allowable EIRP subject to a maximum conducted power allowance as well. The maximum conducted power at the antenna connector can be no more than 30 dBm. The maximum allowable output power of the reader can be set to satisfy both the conductor and radiated maximum criteria. The expression for the maximum reader power setting is:

Maximum power setting (in dBM) = the Smaller of:

(36 – Composite Antenna Gain (in dBM)) OR (30 + Cable Loss (in dBM)),

where the composite antenna gain comprises the maximum linear antenna gain in dBi minus any cable loss between the reader and antenna in dB. Approved antenna vendors, model numbers, and associated gain are listed in the next section.

### Approved Antennas

- Laird Technologies model number S9028PCL/R (left- or right-hand CP), with integrated 8 foot pigtail to RP-TNC male connector; 6 dBi composite gain
- Impinj model number IPJ-A0301-USA (Mini-Guardrail) with SMA female connector; -15 dBi gain
- Impinj model number IPJ-A0310-USA (Threshold-T Antenna) with 12 inch integrated pigtail to BNC male connector, 6 dBi composite gain.
- Impinj model number IPJ-A0400-USA, CSL CS-777-2 (Brickyard) with 7 foot integrated pigtail to RP-TNC male connector; 2 dBi composite gain
- Impinj model number IPJ-A0401-USA or IPJ-A0402-USA (both Guardwall) with 6 foot integrated pigtail to RP-TNC male connector; 6 dBi composite gain
- MA/COM MAAN-000246-FL1 integrated RFID floor-mounted stand (multiple con- figurations available, 2 or 4 antennas left-hand and right-hand CP) with 8 foot integrated pigtail to RP-TNC male connector; 6 dBi composite gain
- MA/COM MAAN-000246-WL1 integrated RFID wall-mounted stand (multiple con- figurations available, 2 antennas left-hand and right-hand CP) with 8 foot integrated pigtail to RP-TNC male connector; 6 dBi composite gain
- MTI MT-262006/TLH (left-hand CP) or MT-262006/TRH (right-hand CP) with RP- TNC female connector (antennas available in IP54 or IP67 ratings); 6 dBi gain
- MTI MT-262013/NLH (left-hand CP) or MT-262013/NRH (right-hand CP) with N- type female connector (antennas available in IP54 or IP67 ratings); 4.5 dBi gain
- MTI MT-262013/TLH (left-hand CP) or MT-262013/TRH (right-hand CP) with RP- TNC female connector (antennas available in IP54 or IP67 ratings); 4.5 dBi gain
- Sensormatic Electronics Corp. model number IDANT20TNA25 with 25 foot Belden 7806A RG-58 coaxial cable (0.1 dB per foot loss) to RP-TNC male connector; 5.5 dBi composite gain

- Sensormatic Electronics Corp. model number IDANT10CNA25 with 25 foot Belden 7806A coaxial cable (0.1 dB per foot loss) to RP-TNC male connector; 3.5 dBi composite gain
- Sensormatic Electronics Corp. model number IDANT10CNA25 with 6 foot Belden 7806A coaxial cable (0.1 dB per foot loss) to RP-TNC male connector; 5.4 dBi composite gain

**Warning**: The use of any antenna not listed above may damage the reader or adversely affect performance.

### Frequency Plans

The GX1 reader operates over a subset of the FCC North American spectrum (902–928 MHz, with specific frequency and channel usage dictated by regulations of each country. Frequency hopping spread spectrum (FHSS) is used, with the exception of Israeli where only a single channel is available. The specific frequency plans by country are listed in the tables that follow.

**Table A.3 Australia operating frequency band is 920 to 926MHz with 500kHz channel spacing.**

| LLRP Channel Number | FCC Channel Number | Center Frequency (MHz) |
|---|---|---|
| 1 | 36 | 920.25 MHz |
| 2 | 37 | 920.75 MHz |
| 3 | 38 | 921.25 MHz |
| 4 | 39 | 921.75 MHz |
| 5 | 40 | 922.25 MHz |
| 6 | 41 | 922.75 MHz |
| 7 | 42 | 923.25 MHz |
| 8 | 43 | 923.75 MHz |
| 9 | 44 | 924.25 MHz |
| 10 | 45 | 924.75 MHz |
| 11 | 46 | 925.25 MHz |
| 12 | 47 | 925.75 MHz |

**Table A.4 Brazil operating frequency band is 902-907.5 and 915-928Mhz with 500kHz channel spacing.**

| LLRP Channel Number | FCC Channel Number | Center Frequency (MHz) |
|---|---|---|
| 1 | 1 | 902.750 |
| 2 | 2 | 903.250 |

| LLRP Channel Number | FCC Channel Number | Center Frequency (MHz) |
|---|---|---|
| 3 | 3 | 903.750 |
| 4 | 4 | 904.250 |
| 5 | 5 | 904.750 |
| 6 | 6 | 905.250 |
| 7 | 7 | 905.750 |
| 8 | 8 | 906.250 |
| 9 | 9 | 906.750 |
| 10 | 10 | 907.250 |
| 11 | 26 | 915.250 |
| 12 | 27 | 915.750 |
| 13 | 28 | 916.250 |
| 14 | 29 | 916.750 |
| 15 | 30 | 917.250 |
| 16 | 31 | 917.750 |
| 17 | 32 | 918.250 |
| 18 | 33 | 918.750 |
| 19 | 34 | 919.250 |
| 20 | 35 | 919.750 |
| 21 | 36 | 920.250 |
| 22 | 37 | 920.750 |
| 23 | 38 | 921.250 |
| 24 | 39 | 921.750 |
| 25 | 40 | 922.250 |
| 26 | 41 | 922.750 |
| 27 | 42 | 923.250 |
| 28 | 43 | 923.750 |
| 29 | 44 | 924.250 |
| 30 | 45 | 924.750 |
| 31 | 46 | 925.250 |
| 32 | 47 | 925.750 |
| 33 | 48 | 926.250 |
| 34 | 49 | 926.750 |

| LLRP Channel Number | FCC Channel Number | Center Frequency (MHz) |
|---|---|---|
| 35 | 50 | 927.250 |

**Table A.5 Hong Kong operating frequency band is 920 to 925MHz with 500kHz channel spacing.**

| LLRP Channel Number | FCC Channel Number | Center Frequency (MHz) |
|---|---|---|
| 1 | 36 | 920.25 MHz |
| 2 | 37 | 920.75 MHz |
| 3 | 38 | 921.25 MHz |
| 4 | 39 | 921.75 MHz |
| 5 | 40 | 922.25 MHz |
| 6 | 41 | 922.75 MHz |
| 7 | 42 | 923.25 MHz |
| 8 | 43 | 923.75 MHz |
| 9 | 44 | 924.25 MHz |
| 10 | 45 | 924.75 MHz |

**Table A.6 Israel operating frequency band is 915 to 917MHz with 500kHz channel spacing with a single channel**

| LLRP Channel Number | FCC Channel Number | Center Frequency (MHz) |
|---|---|---|
| 1 | 28 | 916.25 MHz |

**Table A.7 Malaysia operating frequency band is 919 to 923MHz with 500kHz channel spacing.**

| LLRP Channel Number | FCC Channel Number | Center Frequency (MHz) |
|---|---|---|
| 1 | 34 | 919.25 MHz |
| 2 | 35 | 919.75 MHz |
| 3 | 36 | 920.25 MHz |
| 4 | 37 | 920.75 MHz |
| 5 | 38 | 921.25 MHz |
| 6 | 39 | 921.75 MHz |
| 7 | 40 | 922.25 MHz |
| 8 | 41 | 922.75 MHz |

**Table A.8 Singapore operating frequency band is 920 to 925MHz with 500kHz channel spacing.**

| LLRP Channel Number | FCC Channel Number | Center Frequency (MHz) |
|---|---|---|
| 1 | 36 | 920.25 MHz |
| 2 | 37 | 920.75 MHz |
| 3 | 38 | 921.25 MHz |
| 4 | 39 | 921.75 MHz |
| 5 | 40 | 922.25 MHz |
| 6 | 41 | 922.75 MHz |
| 7 | 42 | 923.25 MHz |
| 8 | 43 | 923.75 MHz |
| 9 | 44 | 924.25 MHz |
| 10 | 45 | 924.75 MHz |

**Table A.9 Taiwan operating frequency band is 922 to 928MHz with 500kHz channel spacing.**

| LLRP Channel Number | FCC Channel Number | Center Frequency (MHz) |
|---|---|---|
| 1 | 40 | 922.25 MHz |
| 2 | 41 | 922.75 MHz |
| 3 | 42 | 923.25 MHz |
| 4 | 43 | 923.75 MHz |
| 5 | 44 | 924.25 MHz |
| 6 | 45 | 924.75 MHz |
| 7 | 46 | 925.25 MHz |
| 8 | 47 | 925.75 MHz |
| 9 | 48 | 926.25 MHz |
| 10 | 49 | 926.75 MHz |
| 11 | 50 | 927.25 MHz |
| 12 | - | 927.75 MHz |

**Table A.10 Thailand operating frequency band is 920 to 925MHz with 500kHz channel spacing.**

| LLRP Channel Number | FCC Channel Number | Center Frequency (MHz) |
|---|---|---|
| 1 | 36 | 920.25 MHz |
| 2 | 37 | 920.75 MHz |
| 3 | 38 | 921.25 MHz |
| 4 | 39 | 921.75 MHz |
| 5 | 40 | 922.25 MHz |
| 6 | 41 | 922.75 MHz |
| 7 | 42 | 923.25 MHz |
| 8 | 43 | 923.75 MHz |
| 9 | 44 | 924.25 MHz |
| 10 | 45 | 924.75 MHz |

**Table A.11 Uruguay operating frequency band is 916 to 928MHz with 500kHz channel spacing.**

| LLRP Channel Number | FCC Channel Number | Center Frequency (MHz) |
|---|---|---|
| 1 | 28 | 916.25 MHz |
| 2 | 29 | 916.75 MHz |
| 3 | 30 | 917.25 MHz |
| 4 | 31 | 917.75 MHz |
| 5 | 32 | 918.25 MHz |
| 6 | 33 | 918.75 MHz |
| 7 | 34 | 919.25 MHz |
| 8 | 35 | 919.75 MHz |
| 9 | 36 | 920.25 MHz |
| 10 | 37 | 920.75 MHz |
| 11 | 38 | 921.25 MHz |
| 12 | 39 | 921.75 MHz |
| 13 | 40 | 922.25 MHz |
| 14 | 41 | 922.75 MHz |
| 15 | 42 | 923.25 MHz |

| LLRP Channel Number | FCC Channel Number | Center Frequency (MHz) |
|---|---|---|
| 16 | 43 | 923.75 MHz |
| 17 | 44 | 924.25 MHz |
| 18 | 45 | 924.75 MHz |
| 19 | 46 | 925.25 MHz |
| 20 | 47 | 925.75 MHz |
| 21 | 48 | 926.25 MHz |
| 22 | 49 | 926.75 MHz |
| 23 | 50 | 927.25 MHz |

**A.12 Vietnam operating frequency band is 920 to 925MHz with 500kHz channel spacing.**

| LLRP Channel Number | FCC Channel Number | Center Frequency (MHz) |
|---|---|---|
| 1 | 36 | 920.25 MHz |
| 2 | 37 | 920.75 MHz |
| 3 | 38 | 921.25 MHz |
| 4 | 39 | 921.75 MHz |
| 5 | 40 | 922.25 MHz |
| 6 | 41 | 922.75 MHz |
| 7 | 42 | 923.25 MHz |
| 8 | 43 | 923.75 MHz |
| 9 | 44 | 924.25 MHz |
| 10 | 45 | 924.75 MHz |

# Appendix B: GPIO Details

Speedway Revolution includes a multipurpose I/O port that contains an RS-232 serial port, four opto-isolated inputs, four opto-isolated outputs, and a +5V supply. You access these features through a DE15 connector mounted on the side of the reader.

The four opto-isolated inputs have a range of 0–30V. The reader treats an input of 0–0.8V as a logic 0, and an input of 3–30V as a logic 1. The reader has a per-input debounce interval that is configurable via LLRP. (See the document titled *Octane LLRP* for more information). This value dictates the minimum pulse width of an input. Impinj recommends that external devices guarantee a minimum pulse width of at least 100 milliseconds.

The reader also provides four opto-isolated outputs. For the GPIO outputs to function, an external user supply must be connected between V+, and V-. The maximum voltage for this supply is 30V. When the user configures a selected GPIO output via LLRP to output logic 0, an isolated FET switch within the reader effectively shorts that output to V- with a current sink capability of up to 200mA. When the user configures a selected GPIO output to logic 1, the selected output is pulled to V+ through a 10K resistor. If GPIO isolation is not required, the reader provides a +5V supply and a ground pin on the DB-15 that can be connected to V+ and V-.

Figure B.1 shows the detailed function of each pin of the GPIO DB-15 connector.

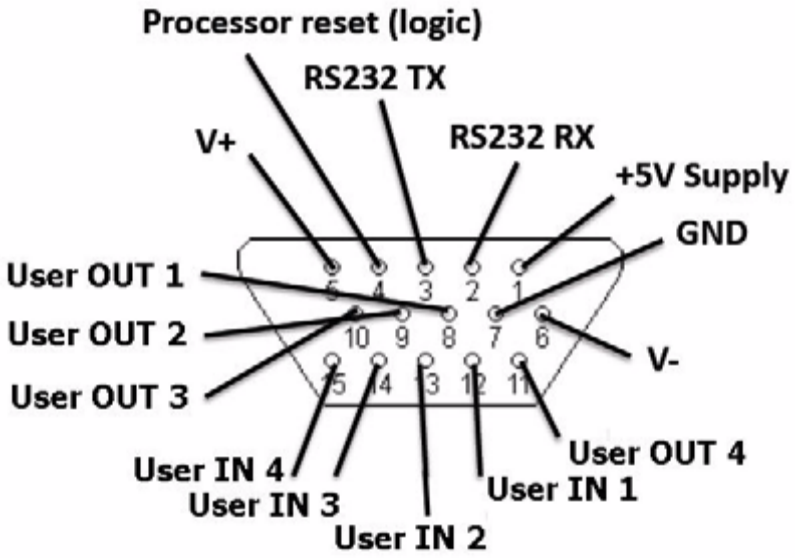



Figure B.1 DB-15 GPIO Port Functions

✓ **Note:** As described above, both the input and output pins are opto-isolated.

Tables B.1 and B.2 further explain the function of each pin.

**Table B1: DB-15 Connector Pin-Out**

| Pin | I/O Name | I/O Function |
|---|---|---|
| 1 | +5V Supply | Reader supplied (not isolated) power source |
| 2 | RS-232 RX | For auxiliary serial port functions |
| 3 | RS-232 | TX For auxiliary serial port functions |
| 4 | Processor Reset | Reserved for future use. . Do not connect this pin to any signal |
| 5 | V+ | Power source for isolated outputs |
| 6 | V- | Return for isolated inputs and outputs |
| 7 | Ground | Reader (not isolated) return |
| 8 | User OUT 1 | Isolated output 1 (active pull down to V-) |
| 9 | User OUT 2 | Isolated output 1 (active pull down to V-) |
| 10 | User OUT 3 | Isolated output 3 (active pull down to V-) |
| 11 | User OUT 4 | Isolated output 4 (active pull down to V-) |
| 12 | User IN 1 | Isolated input 1 |
| 14 | User IN 3 | Isolated input 3 |
| 15 | User IN | 4 Isolated input 4 |

**Table B.2: GPIO Interface Electrical Specification**

| Pin | Parameter | Description | Min | Max | Unit | Conditions |
|---|---|---|---|---|---|---|
| +5V Supply | IO | Output current | | 200 | mA | |
| User IN 1-4 | VIH | HIGH level input voltage | 3 | 30 | V | |
| User IN 1-4 | VIL | LOW level input voltage | 0 | 0.8 | V | |
| User IN 1-4 | VLI | Input current | | 5 | mA | 24V input |
| User IN 1-4 | VI | Input voltage range | 0 | 30 | V | No damage |
| User Out 1-4 | VOH | Output high voltage | | V+* | V | 10K pullup |
| User Out 1-4 | VOL | Output low voltage | | (V-) +0.5 | V | 100mA load |
| User Out 1-4 | VI | Supply voltage range (V+ - V-) | | 30 | V | |

*User-supplied voltage

# Appendix C: Speedway xPortal Installation

This section covers three unique aspects of using the xPortal product

- RF Beam Pattern
- Mounting the xPortal assembly
- Attaching cables via Conduit

## RF Beam Pattern

The Speedway xPortal has antenna beams that point upwards and downwards. This increases the total area covered by the portal. The unit is intended to be mounted at waist height on the wall. The lower beam covers the tag populations near the floor, while the upper beam reads tags at the top of tall pallets. Tags located at waist height are likely to be read by both beams.

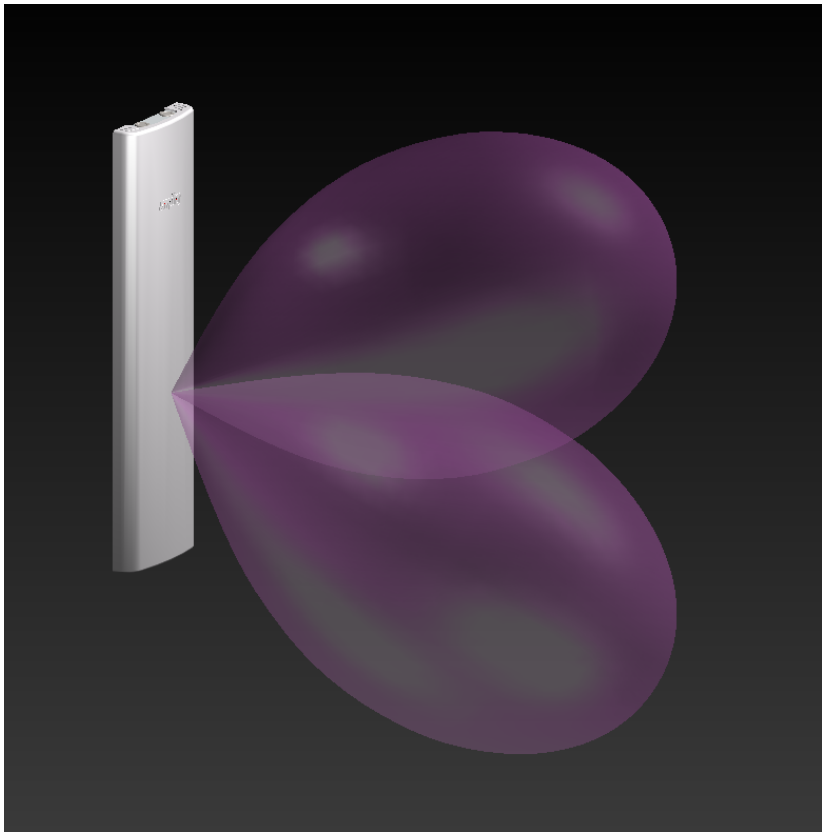


Figure C.1 xPortal Simulated RF Beam Patterns

## Mounting the xPortal

Referring to Figure C.3, the xPortal has many different mounting options:

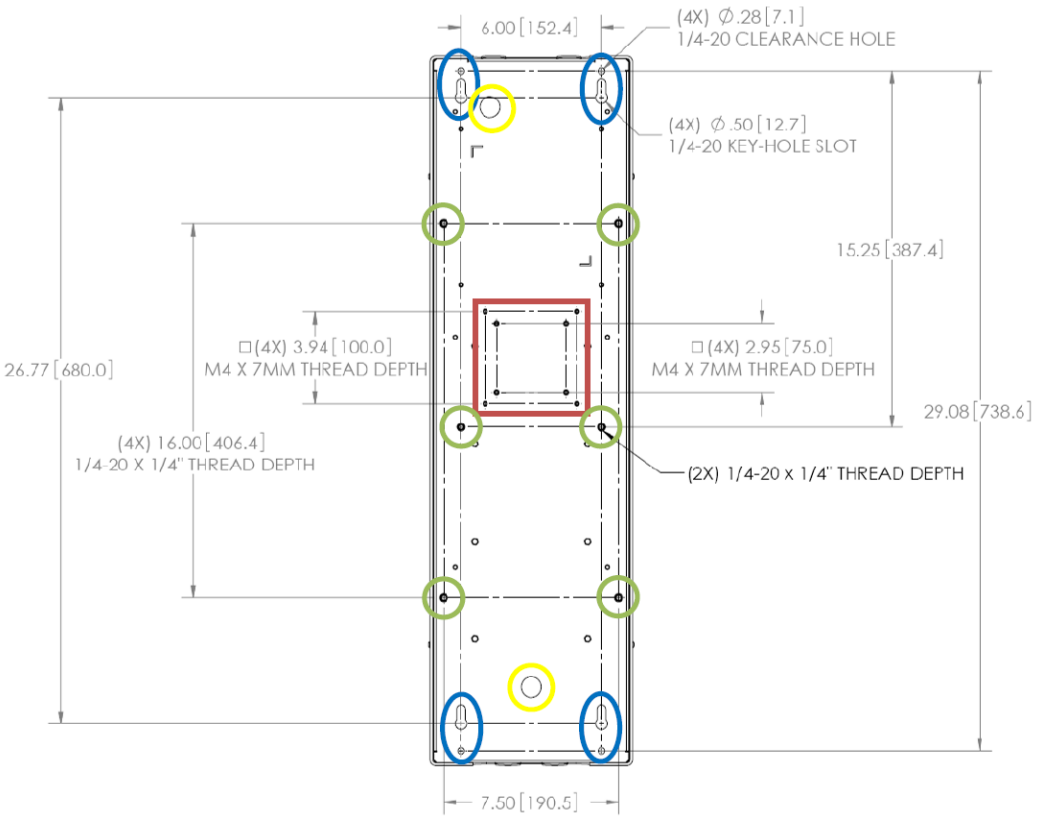
1. Vesa mounts (http://www.vesa.org/) is a standard LCD screen / computer monitor mounting pattern. There are many off the shelf brackets, arms, and stands that use this hole pattern.  Shown in the red square on the figure.

- 8 total holes with M4 threads
- Outer square pattern is 100mm on each side
- Inner square pattern is 75 mm on each side
- ¼-20 internally threaded studs

2. Common hardware using 1/4-20 hardware. This hardware is typically employed in most T-slot extrusion designs (see http://www.8020.net/). Show in the Green circles on the figure.
3. Keyhole slots and through-holes. Holes are sized to allow clearance for 1/4-20 screws. These holes allow you to mount the unit flush to a wall. Shown in the Blue ovals on the figure.

It is your responsibility to determine if the chosen screws can support the weight of the xPortal. Since the xPortal only weighs approximately 6.5 pounds (3kg), it can even be installed on drywall without needing to locate studs.

The Yellow circles on the figure highlight two knock-outs that can be removed if you wish to run cables into the unit directly from the wall. This provides a very clean installation, with no cables visible from the front.




**FigureC.3 xPortal Mounting Hole Types and Locations**

## Conduit Attachment

The round openings in the top and bottom of xPortal are designed so you can run metallic conduit directly to the unit. This allows Ethernet or power cables to be protected by standard EMT (electrical metallic tubing). The holes are sized for ½" trade size conduit connectors, or where metric conduit is used, 16mm trade size. Larger sizes of conduit (such as ¾") can be used with the proper adapters, see example #3 below.

The following photos highlight the usage options.

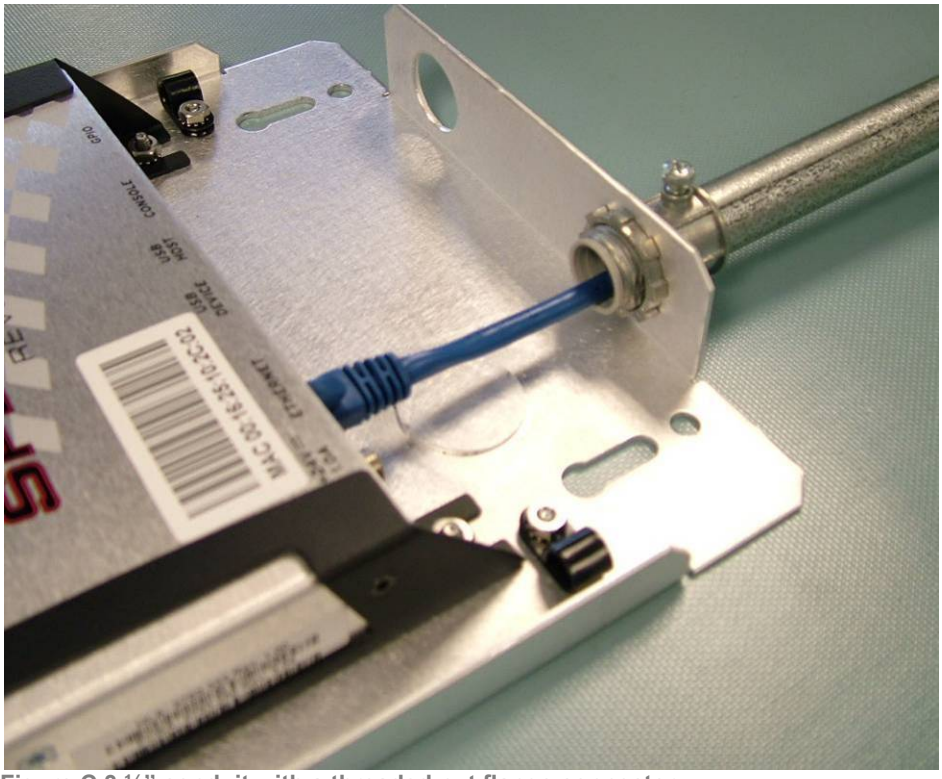


**Figure C.3 ½" conduit with a threaded nut flange connector**

**Figure C.4 Threaded ½" conduit connector**

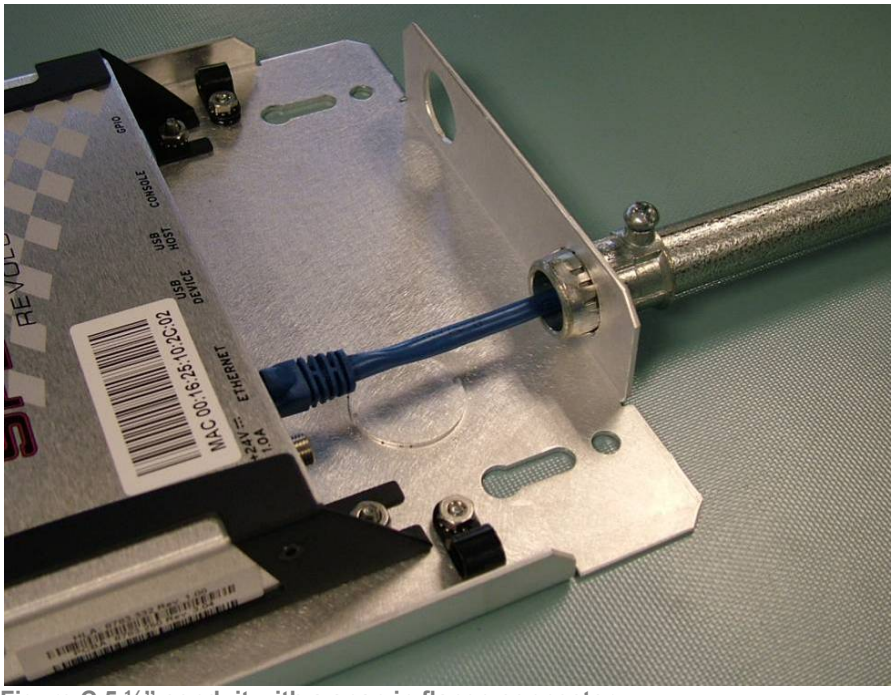



**Figure C.5 ½" conduit with a snap in flange connector**

**Figure C.6 Snap in ½" conduit connector**

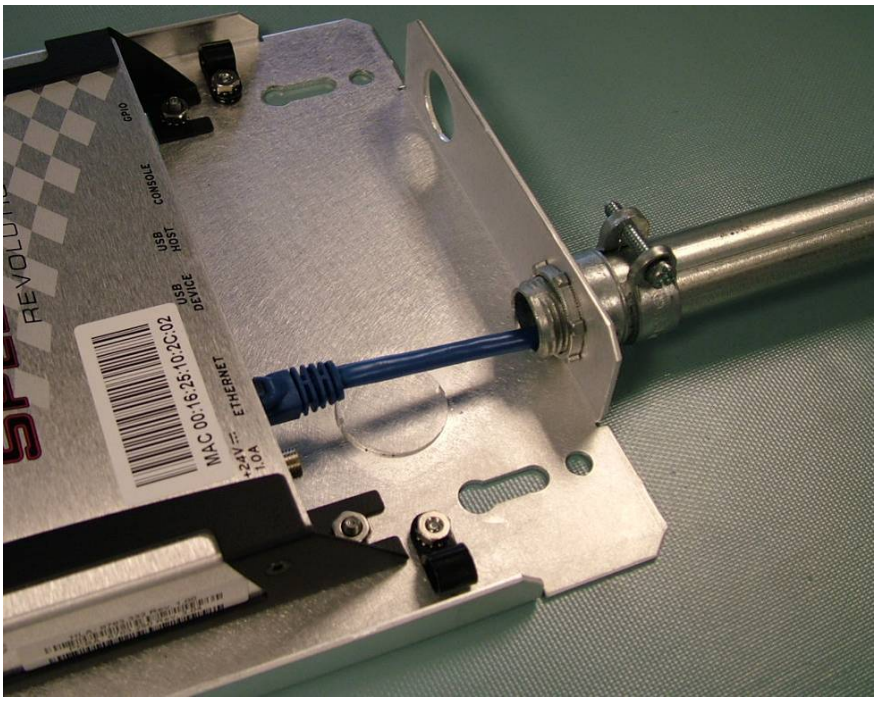



**Figure C.7 A squeeze connector for the larger ¾" conduit tubing size. The connector has a nut and threads sized for the ½" conduit hole.**

**Figure C.8 ¾” conduit squeeze connector, with a threaded interface to ½” conduit hole**

**Notices**

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