# FMR-6000 User Manual

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**Caution**

This device should be operated with a minimum distance of at least 23 cm between its antennas and a person's body in keeping with RF exposure limits in Council Recommendation 1999/519/EU, FCC 2.1091 and Industry Canada RSS-102.

## Intelleflex Contact Information

## Corporate Headquarters

| | |
|---|---|
| **Web Site** | http://www.intelleflex.com |
| **Telephone** | +1.408.200.6500 |
| | US Toll-Free: 1.877.694.3539 |
| **Fax** | +1.408.200.6599 |
| **Customer Support** | support@intelleflex.com<br>+1.408.200.6520 |
| **Mail Address** | Intelleflex Corporation<br>2465 Augustine Drive #102<br>Santa Clara, CA 95054 |

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# 1. Introduction

The Intelleflex Fixed Multi-Protocol Reader (FMR) 6000 is a fixed infrastructure RFID reader that provides extended capabilities with industry-leading range and read/write reliability. The FMR-6000 advanced design ensures easy field upgradeability to new,enhanced features, as well as support for ISO 18000-6.1 C Class 3 and EPC-global C1G2 industry standards.

This user manual describes the installation and operation of the Intelleflex FMR-6000 UHF RFID Reader. This manual is intended for, but not limited to, Intelleflex RFID software developers integrating the FMR-6000 into a new or existing RFID solution.

# 2. The Intelleflex FMR-6000

## 2.1 Overview

The FMR-6000 can support connections through Ethernet, host web and Java applications directly on the reader, be triggered by up to two different relay networks through the opto-isolated GPIO connector, and connect up to two pairs of bi-static, circularly (or linearly) polarized antennas.

Powering the FMR-6000 is done through a Power over Ethernet (PoE) connector.  Powering the unit and setting up the LAN connection can be done one of two ways: connect the unit directly to a network switch or router that supports PoE, or by injecting power into an already exciting LAN cable through a PoE injector power supply (this is provided by Intelleflex with the FMR-6000).
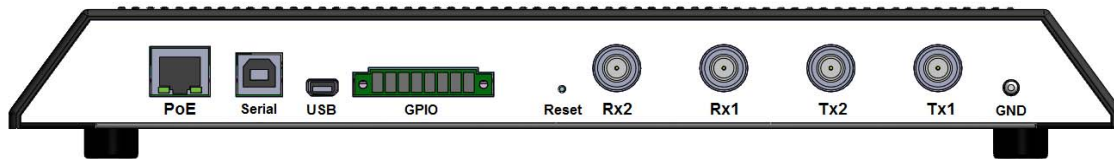
Figure 2.1-1 FMR-6000 Back Connector Panel

When using the FMR-6000, be sure to always have antennas connected to at least one pair of antenna ports – This is imperative to ensure proper behavior of the unit.

## 2.2 Hardware Specifications

**SPECIFICATIONS**

| | |
|---|---|
| **Physical Characteristics** | |
| Dimensions | 12.27 x 6.85 x 1.36 inches (311.62 x 174 x 34.5 mm) |
| Weight | 2.9 lbs. (1.32 kg) |
| **Connectivity** | |
| External Interfaces | Ethernet RJ45, USB type mini AB, serial over USB type B, GPIO |
| RF Connector Type | Reverse Polarity TNC |
| Antenna Ports | 2 transmit, 2 reverse (2 bi-static pairs) |
| Power Supply | IEEE 802.3af PoE 48V (single) |
| **Protocol** | |
| Standards | EPC C1G2 passive, ISO 18000-6C revision 1 Manchester BAP |
| C1G2 PIE forward link Tari | 25 - 6.25 µsec |
| C3 Manchester forward link rates | 8 - 128 Kbps |
| Miller backscatter link frequencies, M ratio | BLF: 80 - 320 KHz, M: 2 – 128 |
| Reverse link data rates (BLF/M) | 2.5 – 160 Kbps |
| **Performance** | |
| Tag maximum read rate | 200 tag inventories/sec (C1G2) |
| Tag maximum range | C1G2 up to 10 m;  C3 up to 100 m |
| Transmitter RF Output Power | 0 to +30 dBm, 1 dB steps, +/- 1 dB accuracy |
| Receiver Sensitivity | -125 dBm at 2.5 Kbps |
| Frequency Range | EU 865-867 MHz, FCC 902-928 MHz; Regulatory dependent |
| Number of Channels | 4 – 50; Regulatory dependent |
| **Environmental** | |
| **Temperature** | |
| Operating | 0° to +55°C |
| Storage | -20° to +70°C |
| Humidity Standard | IEC 60068-30/78, 5-95% non-condensing |
| Vibration Standard | IEC 60068-2-6 |
| **Compliance/Certifications** | |
| EMC | |
| Agency Listings | |
| RoHS | |
| **Hardware And F/W Management** | |
| Firmware Upgrade | Host based firmware upgrade capabilities |
| Host Interface Protocols | Serial port, HDLC formatting |
| **Software Support** | |
| Windows DLL | |
| XML | Multi-platform interface |
| Temperature sensor tag API | |
| .NET support | Compatible with Microsoft® .NET Compact Framework |

## 2.3 Detailed System Specifications

### 2.3.1 Antennas

There are four Reverse Polarity (RP) threaded Neill-Concelman (TNC), RP-TNC, connectors on the FMR-6000. These connectors are separated into pairs, two are dedicated for transmit and two are dedicated for receive. At a minimum one pair of antennas needs to be connected: a "pair" consisting of one transmit antenna and one receive antenna.

Mounting hardware is provided with the antennas to easily attach antennas either to a pole or wall. A mounting instruction sheet is provided with the mounting hardware. Mount one antenna pair such that antennas are at least six feet above the ground. To maximize read range, space the Transmit (Tx) and Receive (Rx) antennas at least a foot apart. You can also mount the antennas side-by-side (horizontally) so long as a minimum separation of one foot is maintained. Be sure to verify the antennas are connected to the correct ports; the antenna's function is labeled on the back of the antenna.
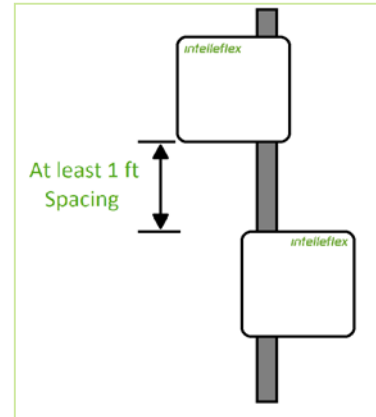
Figure 2.3-1 Tx and Rx antenna spacing

Connect the Tx antenna to the Tx port on the reader, and Rx antenna to the Rx port on the reader. Use the supplied RF cables with reverse TNC connecters.

Up to four antenna pairs may be connected to the reader at any given time. When several Rx and Tx antennas are connected, the reader can be set up to transmit on any Tx port and receive on any Rx port.

### 2.3.2 Serial Connection

There is a direct serial connection port on the FMR-6000 that allows for a PC to establish a connection with the reader through a standard USB cable. This creates a Virtual Communication Port (VCP) that allows PCs without serial ports to connect directly to the reader without buying a Serial to USB adapter. Drivers to support this feature can be found at the FTDI website, or by following the link provided: http://www.ftdichip.com/Drivers/VCP.htm

Once the driver is installed and the USB cable is connected to both the reader and the PC, opening up a serial connection can be done easily on both Windows or OS X for Mac based systems. To connect over serial on a specific system please see Appendix A for specific details. Once a connection is made to the reader power on the reader by plugging in the Ethernet cable using the power injector (see next section for details) and allow the unit to boot. When the unit has booted all the way, you will see the print out on the screen as in Figure 2.3-2.

```
****************************************
Prod: FMR-6000
Name: Intelleflex Reader
S/N: IA210430011
Ver: 3.0.2.0.707
Rel Date: 2010-10-27 12:24:37 -0700
IP: 10.1.6.139
netmask: 255.255.255.0
gateway: 10.1.6.1
broadcast: 10.1.6.255
mac: 64:7B:D4:08:10:AD
using DHCP: no
****************************************
****************************************
** Intelleflex Reader @ 10.1.6.139 **
**    3.0.2.0.707 - IA210430011    **
****************************************
**
** 1 - Set static IP              **
** 2 - Set to DHCP networking     **
** 3 - Restore factory defaults   **
** 4 - Display network settings   **
** 5 - Reboot reader              **
**
****************************************
```

Figure 2.3-2 Serial Port Boot Output

### 2.3.3 Power over Ethernet (PoE) and Connecting to a Network

The Intelleflex FMR-6000 is powered via an RJ45 connector and two standard CAT 5 Ethernet cables. One cable plugs into the reader and into the power injector power supply provided by Intelleflex. This injector looks like a standard power supply but has two RJ45 ports on one side and a power cord socket on the other. Plug the reader's CAT 5 Ethernet cable into the "LAN + DC" RJ45 socket on the injector. Then using the other LAN cable, connect the "LAN" RJ45 socket into a standard DCHP router. Plug the power cord into a wall socket and insert it into the power injector. The "STANDBY" light should illuminate and the reader should begin booting.

Any 802.3af PoE compliant power sourcing equipment (PSE) such as a switch or hub that is capable of sourcing 15.5 watts will also work with the FMR-6000. If your infrastructure already has a PoE switch, ensure that it is 802.3af compliant before using it as a source of power instead of the supplied power injector.

### 2.3.4 Status and Activity LEDs

There are five active LEDs on the front right corner of the FMR-6000.  They are used to see the status or activity level of the reader. When a reader is first plugged in, the *Power* LED will illuminate and stay illuminated until power is removed from the PoE.

The next two lights to turn on will be *Boot* and *Network*. *Boot* will light up when the host application is ready to accept connections. *Network* will light up when the DHCP client has started and is ready to accept a network connection from a DHCP server, or when the reader has assigned itself a static IP address.



Figure 2.3-3 LED Activity and Status Lights

*Transmit* is a dynamic light that will flicker whenever the FMR-6000 is transmitting RF signals out of either of the antenna ports. This light does not necessarily indicate it is finding tags, only that RF is successfully being broadcasted from the reader. The light will flicker (or pulse) at a rate that is dependent on the length and duty cycle of the transmission.  If the reader is assigned to read the full content of user memory, the light will be illuminated until the transmission has ended.

*Fault* is an error triggered LED that will stay illuminated if there is a system error.  If the *Fault* light is illuminated on your FMR-6000 please contact Intelleflex Technical Support (information found at the beginning and end of this document) to get the reader serviced at your earliest convenience. *Note: The Fault light will be illuminated for a few seconds during boot and will then go out when the boot sequence has successfully completed.*

## 2.3.5 General Purpose I/O

There are four digital General Purpose Input and Output (GPIO) ports on the FMR-6000 that are accessed through the provided 8 pin screw head connector. There are two opto-isolated inputs, two open drain outputs, Ground pin, and +5v pin.
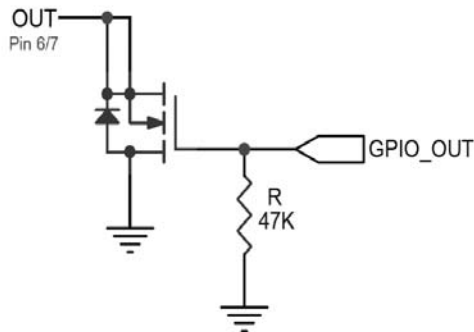


Figure 2.3-4 Optically Isolated Input Schematic

The inputs are differential optically isolated inputs. A differential input provided on the positive and negative side of each input will drive either a positive (logic 1) or negative (logic 0) voltage through the isolator. There is a 1k resistor in series with the positive input pin on each input. See the schematic in Figure 2.3.5.1.

The outputs are open-drain, driven by a MOSFET, and will either drive the pin to a ground, closing the MOSGET, by providing a digital 1 logic level or become a high impedance output, opening the MOSFET, by providing a digital 0 logic level.
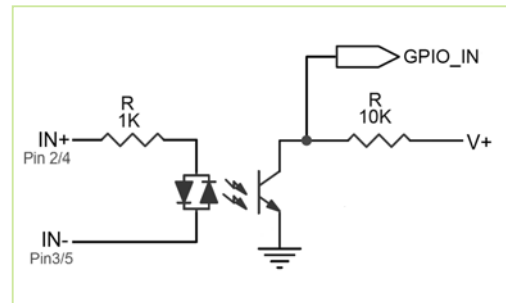
On the readers back panel, located just left of middle, is the green GPIO socket that the provided screw terminal fits into. The screw header fits securely into the socket and is tightened down with the two attached screws.



Figure 2.3-5 Open-Drain Digital Output

Looking at the reader, the pins are numbered left to right from eight (8) to one (1). See Figure 2.3-6 for details and Table 2.3-1 for the pin out.
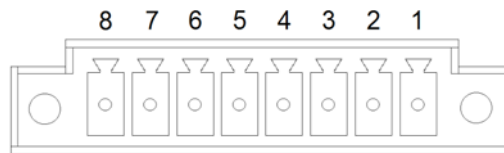


Figure 2.3-6 8 Pin GPIO Header (Looking at the Reader)

Table 2.3-1 Pin Description and Power Characteristics

| Pin | Description | Characteristics |
|-----|-------------|-----------------|
| 1 | Vdd | 5v @ 50mA |
| 2 | IN 1+ (pos) | Max Current |
| 3 | IN 1- (neg) | 10mA |
| 4 | IN 2+ (pos) | Max Current |
| 5 | IN 2- (neg) | 10mA |
| 6 | OUT 1 | 62v@100mA Max |
| 7 | OUT 2 | 62v@100mA Max |
| 8 | GND | |

## 2.3.6 Reader Mounting

The case of the FMR-6000 has been designed with included mounting holes located on either side of the case. When mounting the reader, keep the antenna cables and where they are going to route in mind. If mounting the unit outside or in an industrial area, consider using a NEMA enclosure to protect the unit.
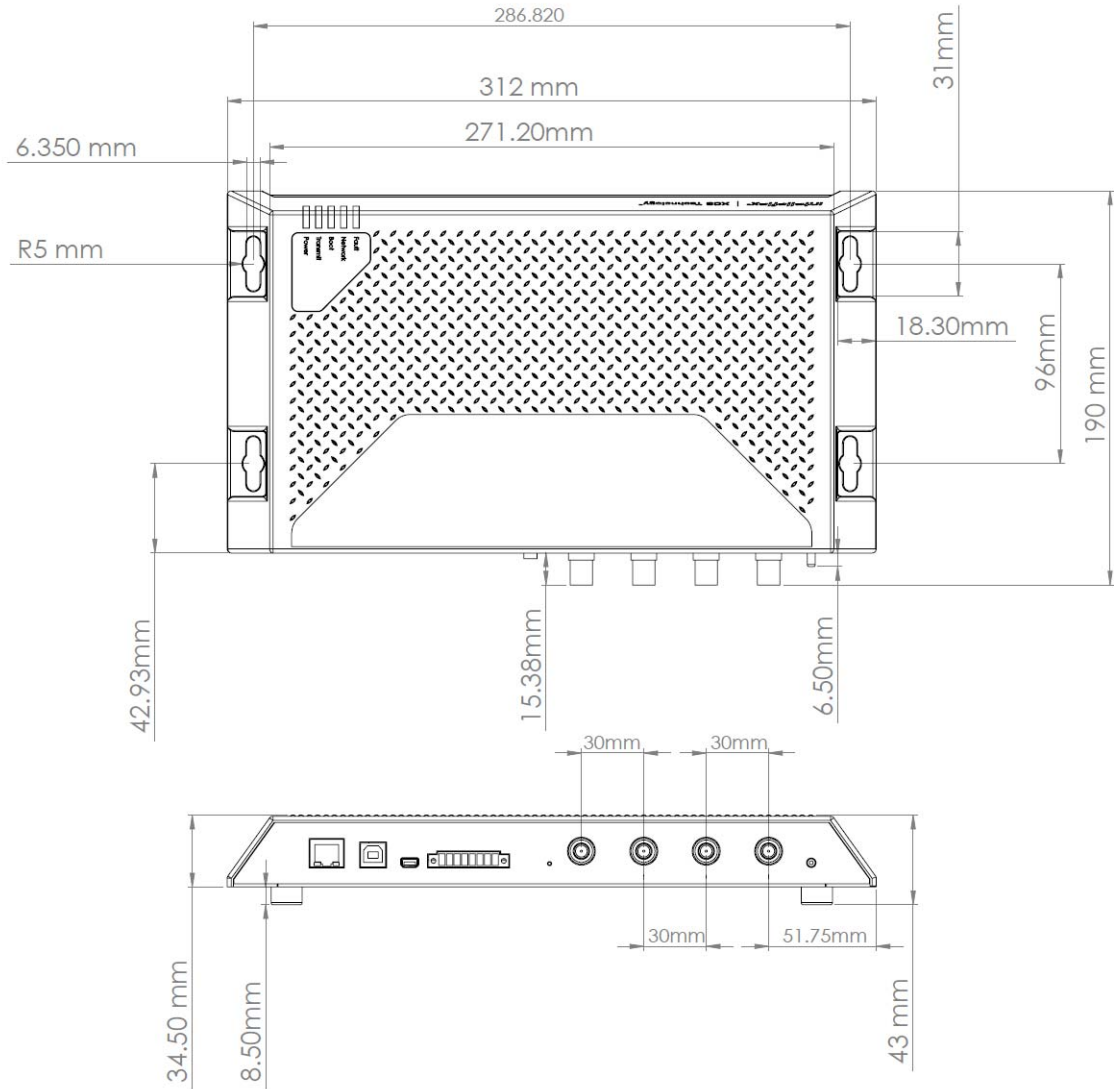
# 3. Reader Web Based Interface

The test interface to the FMR-6000 is a web browser enabled GUI through which the user may interact with the reader. This interface is based on a web server that resides on the reader. Through this interface, the user can set the reader's name, upgrade the reader with new firmware, choose a static IP address or enable DHCP, and check status and version numbers. The user can then inventory C3 or C1G2 tag IDs and interact with tag memory.

## 3.1 Establishing a Connection

The FMR-6000 reader supports only Mozilla Firefox (versions 2 and above).

*Note: Support for Microsoft Internet Explorer is currently not available for the FMR-6000 demonstration pages.*

For More information about obtaining the IP address of the reader please see Section 2.3.2. Once the reader's IP address is known, type in the IP address of the reader (e.g., http://10.1.7.90) into the browser address bar, the reader interface will appear and the status screen will be displayed by default.

## 3.2 Checking Versions and Status

Upon successfully connecting to the reader, the browser defaults to the status page. From this page the Firmware Version of the reader can be determined ("Software Version"), as well as the Serial Number and MAC Address.
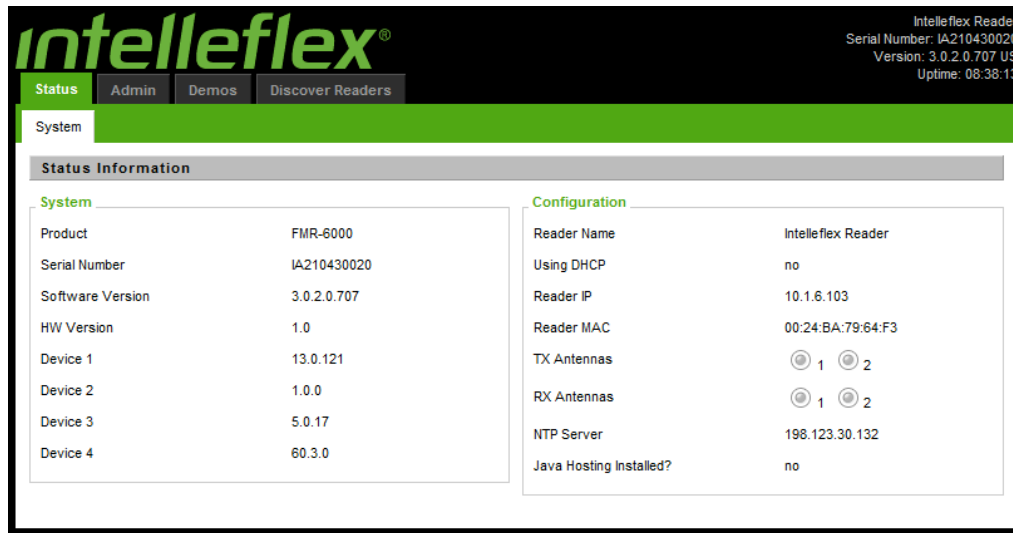


Figure 3.2-1 Status and System Page

## 3.3 Manually Setting to Static or DHCP

From the Admin/Management tags, the Reader Name, Network Setup, and NTP server can be dynamically configured. Be sure to talk to your network administrator before assigning a static IP address to the reader as this can create IP conflicts on your network and will cause the FMR-6000 to not properly respond to commands.
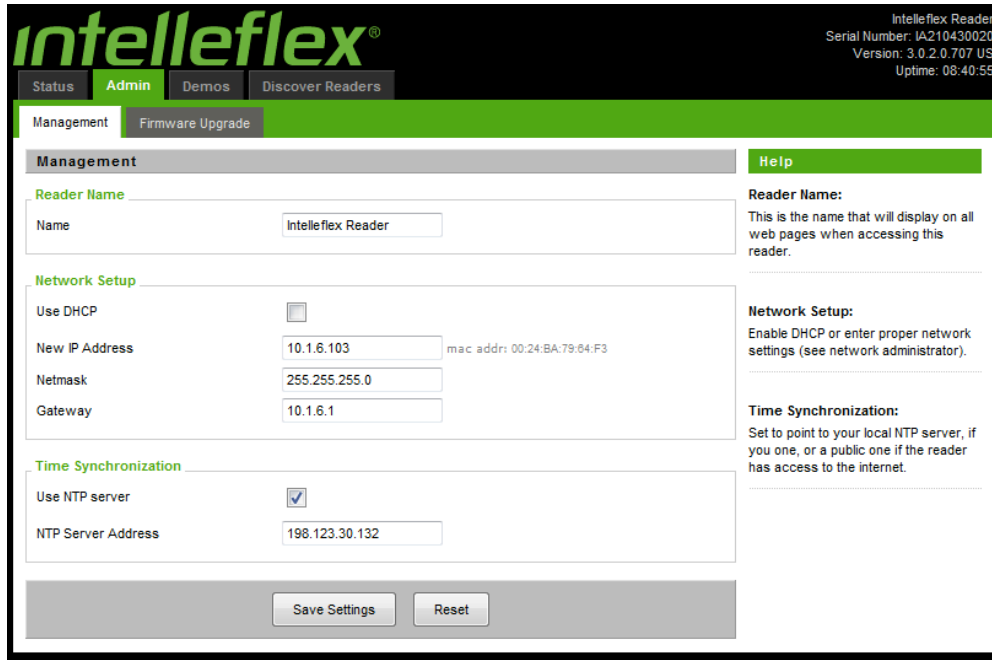
Figure 3.3-1 Admin Management Page

## 3.4 Upgrading Reader Firmware

Upgrading the Firmware on the FMR-6000 is done through the "Firmware Upgrade" tab under "Admin". Obtain the latest version of the FW through the Intelleflex website or contact the Intelleflex Support department if you believe that your firmware version is out of date or if you are experiencing any problems using the web based interface.
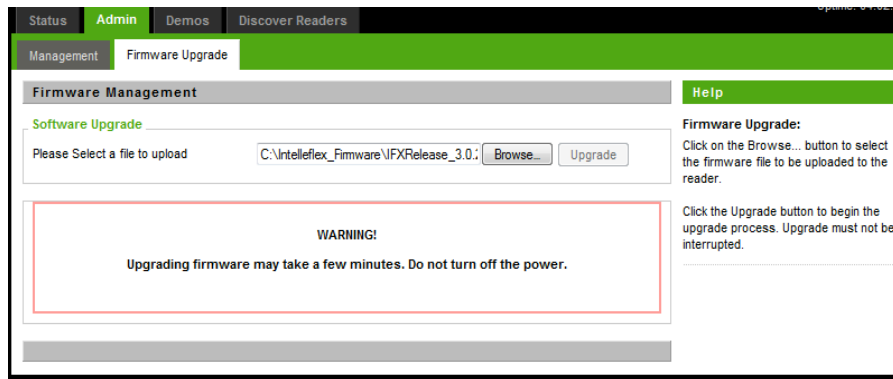


Figure 3.4-1 Reader Firmware Upgrade Page

## 3.5 Basic Inventory Demo

The Demo's tag Inventory page is the main page used to interface with tags. From this page the user has the ability to inventory tags with different RF and reader parameters, read and write to tag user memory, and verify functionality of the system. The
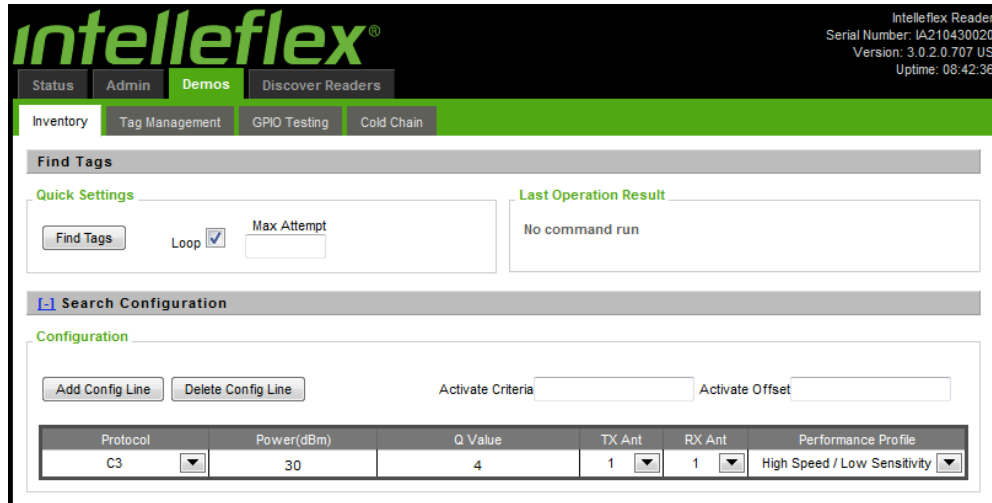
Figure 3.5-1 Inventory and Search Configuration Page

Reader parameters are controlled via "config" lines. A single config line or multiple config lines may be used. A config line is a command sent to the reader telling it what parameters and settings to use during an inventory action. Within each config line, the following reader parameters can be set:

- Protocol – C3 or C1G2
- Power level in dBm, between 0 and +30 dBm
- Q value, between 0 and 13
- Tx and Rx antenna
- Performance Profile

**Protocol:** Select C3 or C1G2 operation from the Protocol dropdown menu. Two config lines can be used to have the reader read a mixed tag population simultaneously.

**Power:** Set between 0 and full power of +30 dBm. Use full power to read C3 tags at long range. Note: Maximum output powers allowed by regulations are dependent on transmit antenna gain. In the United States and Canada the following limits apply:

| Antenna Gain | Maximum Power setting, dBm |
|---|---|
| 9  dBic | 28 |
| 7.5 dBic | 30 |

**Q value:** This value defines the number of time slots that are included in a Query. Total time slots = $2^Q$. On average having more slots than tags in the field is better than having too few. On a general rule of thumb using twice as many slots as tags works well, with the exception of very large populations of tags.

**Tx ant:** Select transmit antenna
**Rx ant:** Select receive antenna

**Performance Profile:** Changing this value will change the performance of the system; by selecting "High Speed/Low Sensitivity" the system will perform inventories as fast as possible at the expense of read distance. "Medium Speed & Sensitivity" is a middle balance between speed and read distance. "Low Speed / High Sensitivity" is going to perform very slowly relative to the other two, but will maximize read distance and performance in challenging RF environments.

**Loop:** Check this box for the reader to repeatedly execute the defined set of config lines. Leave it unchecked to execute each defined config line once and only once, before stopping reads.
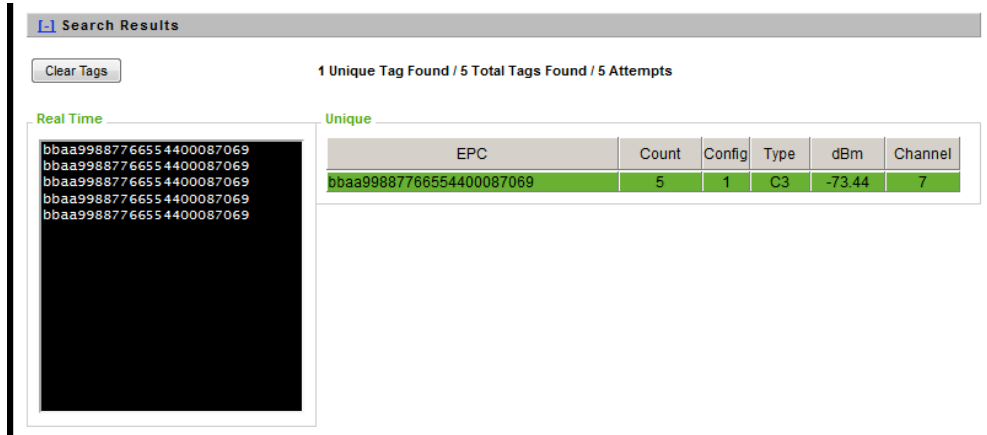
Search Results



Figure 3.5-2 Search Results with a tag Found

The black window on the left shows the tag ID of each tag, as it is read. Text from this window may be copied into a document, if needed. The window holds the last 100 tag IDs read.

The summary window on the right displays the unique tag IDs of identified tags, number of times that tag was read, the config line that most recently found the tag, the tag type (C3 or C1G2), and the dBm value of the Received Signal Strength Indicator (RSSI). Each field may be sorted by clicking on the corresponding gray header (i.e. to sort by protocol, click "Type").

A summary of reads is also displayed above the unique tag reads window. At the top right corner of the Find Tags window, the Last Operation Result section displays the status of the most current command, giving the user some real time feedback on reader operation.

## 3.6 Basic Memory Reader and Write Demo

The web based demonstration page includes a simple tag memory management page that allows you to read and write hexadecimal data in and out of the tag. Access to the memory is given by "Block" address and an offset.  In all Intelleflex XC3 tags there is 60 kilobits of user memory that is broken up into 60 1kbit "Blocks". To access the "Manage Tag Memory" section on the Demo page, find a tag and double click on the tag in the search results viewing area. The window in Figure 3.6-1 will show after double clicking on the tag.
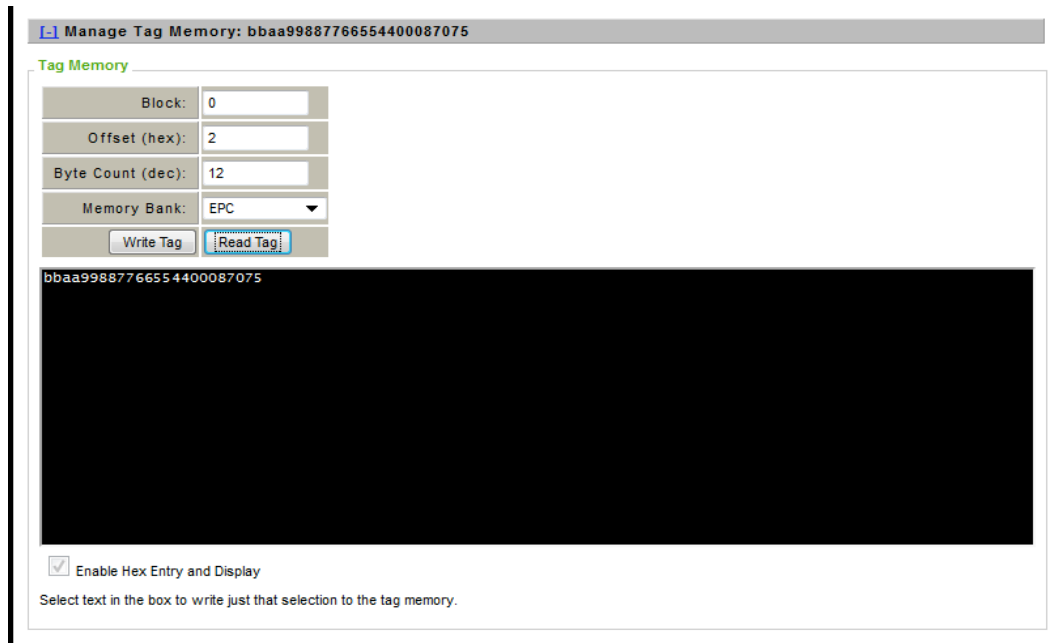
Figure 3.6-1 Tag EPC Read from Tag Memory Management Page

By Selecting the EPC Memory Bank and an Offset of 2 with a length of 12 bytes, the FMR-6000 will read the EPC data that is stored in the tag. All of user memory can also be read and written to in the same way that the EPC memory was accessed here.

## 3.7 GPIO Testing and Verification Page

The GPIO Testing page enables the FMR-6000 to either set or detect the logic levels of the general purpose inputs or outputs. See Section 2.5 for more information about the General Purpose I/O.
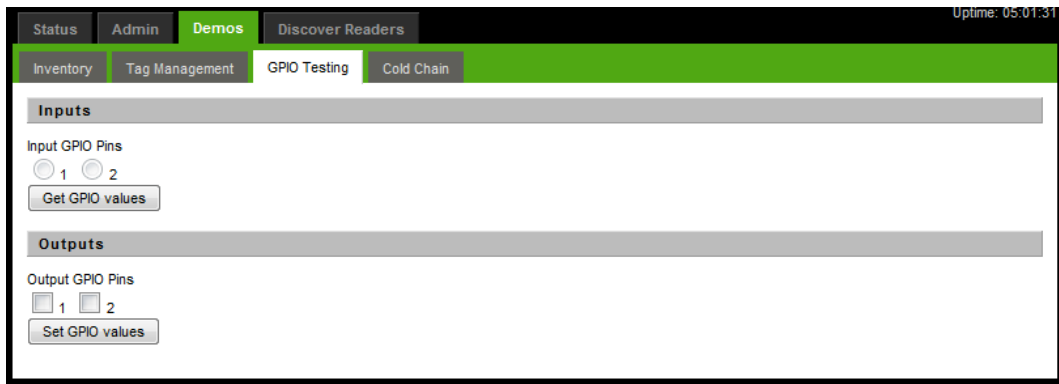


Figure 3.7-1 GPIO Test and Verification Webpage

# 4. Troubleshooting tips

## 4.1 Reader is unresponsive

- Verify that the reader is powered, the power adapter LED is on, and the three recessed lights on the back of the reader above the serial connector are on.

- Power cycle the reader. After all three lights come on, connect to the reader.

- Verify network connectivity. Check reader and host IP address and ping the reader.

## 4.2 Reader is not reading tags

- Verify that at least one pair of antennas (one Tx and one Rx) are connected and attached to the appropriate ports on the reader.

- Verify that the correct antennas pairs are activated from the Config/reader page.

- From the Demo/test page, verify that that the config line specifies the correct Tx and Rx pair.

- Ensure that the correct config line parameters have been set; to test the reader set the following parameters: protocol (C3 or C1G2), power (set full power at +30 dBm), Q value (set between 4 and 6), select the right Tx and Rx antennas. Set forward link and reverse link to 8 kbps, and Inventory to Portal mode.

- Try to read different tags, to eliminate a bad tag.

- Make sure that proper tags are being used for the application. For example, use a mount-on-metal tag for a metal mount application.

- Make sure that you are using the appropriate Performance Profile for your application, if it is not reading the tag in a difficult RF environment, try selecting a slower, yet more RF robust, sensitive profile.

## 4.3 Reader response is slow or sluggish

- Multiple configuration lines will slow the reader down, Use one configuration line if you want the fastest response.

- Check Q value. For larger tag populations, higher Q should be used. In general, avoid Q values greater than 9.

- Make sure that you are using the appropriate Performance Profile for your application. If it is reading too slowly for your needs, try selecting a less sensitive profile.

# Appendix A Establishing a Serial Connection

## 4.4  For Windows:

## 4.5  For OS X ( Linux):

## Regulatory Information and Documentation

*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.*

NOTE:  Changes or modifications not expressly approved by Intelleflex Corporation may void the user's authority to operate the equipment.

NOTE: 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 residential installation. 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.
-- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
-- Consult the dealer or an experienced radio/TV technician for help.

This device has been designed to operate with the antennas listed below, and having a maximum gain of 9dBic.   Antennas not included in this list or having a gain greater than 9dBic  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.

## Declaration of Conformity

# Technical Support

For technical assistance and reader service and repair, please contact Technical Support

Toll-Free: 1-877-694-3539
International: +1-408-200-6500

-or-

E-mail support@intelleflex.com

If the reader needs to be returned for service, please fill out the warranty card included with developer's kit and call in to receive a Return Materials Authorization (RMA) number and instructions on how to return the reader or visit Intelleflex.com for more detail.