OMRON

V740-series

RFID Reader/Writer Antenna

Operation Manual

V740-BA50C02-US	2 Ports - Reader/Writer
V740-BA50C22-US	4 Ports - Reader/Writer
V740-HS02C	Dual Patch Antenna

The OMRON V740 RFID Reader/Writer (herein after denoted as Reader) uses RFID (radio frequency identification) technology to read data stored on RFID tags. The Reader operates analogous to an SQL (structured query language) server, providing tag data in response to requests from another application. A separate software application may be used to direct its operation and provide a user interface.

The Reader supports UHF (ultra high frequency) antennas, which are available separately. The Reader supports multiple configurations of UHF antenna ports and transfers data to a remote computer over a network connection.

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About this Guide

This installation and usage guide explains how to install the V740 Reader, how to use the browser-based interface, and how to control the Reader remotely. .

Use the instructions provided with the antennas to install and service the antennas.

Note: Because customer requirements dictate the placement of Reader and antenna components, your OMRON representative will supply this information separately.

Before You Begin

Installation Requirements

- The Reader is shipped with a certified limited power source with a cable length of 1.8m (6ft).
- Use only authorized antennas and cables to maintain FCC approval (see page 3).
- In order to comply with FCC requirements for RF exposure safety, a separation distance of at least 21 cm (8.3 in) needs to be maintained between the radiating elements of the antenna and the bodies of nearby persons.
- Provide strain relief for all Reader connections.
- The minimum screw size for mounting the Reader is #12 (M5). Use suitable wall anchors when mounting to drywall or masonry.
- An Shielded Ethernet cable must be used to communicate with other devices.
- Multiple Readers and antennas can be used in combination to enhance detection at specific locations provided the software application is able to synchronize antenna operation.
- Recommended minimum configuration for a computer running an application that interfaces with the V740 Reader:
  - Pentium® 400 MHz processor
  - 128MB memory
  - 10 GB hard drive
  - Microsoft® Windows® 2000 or Windows XP operating system
  - Base-T-10/100 Ethernet® port
  - CD-ROM drive

Performance Considerations

Reader performance may be affected by external factors including tag variables and environment.

Performance tests conducted under typical operating conditions at your site are recommended to help you optimize system performance.

Tag Variables

There are several variables associated with tags that can affect Reader performance:

- Application surface — Some materials interfere with tag performance including metal and moisture. Tags applied to items made from or containing these materials may not perform as expected.
- Tag orientation — Reader performance is affected by the orientation of the tag in the antenna field.
- Tag model — many tag models are available. Each model has its own performance characteristics.

Environment

Reader performance may be affected by the following:

- Metal surfaces such as desks, filing cabinets, bookshelves, and wastebaskets may enhance or degrade Reader performance.

  Mount antennas as far as possible from metal surfaces that are adversely affecting system performance.
- Devices that operate at 900 MHz, such as cordless phones and wireless LANs, can interfere with Reader performance.

  These devices may degrade performance of the Reader. The Reader may also adversely affect performance of 900 MHz devices.
- Antennas operating in close proximity may interfere with one another, thus degrading Reader performance.
- Interference from other antennas may be eliminated or reduced by using either one or both of the following strategies:
  - Affected antennas may be synchronized by a separate user application using a time-multiplexing strategy.

– Antenna power can be reduced by reconfiguring the RF Transmit Power setting for the Reader.

Authorized Antennas

The only antennas authorized by the FCC for use with the V740 Reader/Writer are listed below. Detailed information on each antenna is available from their respective manufacturers.

IMPORTANT: No other antennas may be used with the V740 Reader/Writer without violating FCC regulations. It is the responsibility of the user to comply with this requirement.

OMRON Dual Patch Antenna

Model: V740-HS02C
Gain: 6 dBi max.
Connector: Reverse TNC

Antenna Cables

The only cables authorized by the FCC for use with the V740 Reader/Writerare listed below:

Short R-TNC/N

Model: V740-A01-3.0M
Length: 9.8'
Insertion Loss: 1.4 dB min.
Cable Type: 3D-2V
Connectors: Reverse TNC to Type N

Long R-TNC/N

Model: V740-A01-10M
Length: 32.8'
Insertion Loss: 1.5 dB min.
Cable Type: 5D-SFA
Connectors: Reverse TNC to Type N

Setting the Reader RF Power

During initial installation, the Reader must be properly configured to use the correct RF power to comply with FCC regulations. DO NOT increase the power beyond this level.

The maximum RF power is determined from antenna gain and antenna cable loss using the formula:

Pmax = 36 dBm - Antenna Gain + Cable Loss

For example, if the antenna has a maximum gain of 6 dBi, and the cable has a minimum loss of 1.4 dB, the maximum RF power that may be set is (36-6 + 1.4) = 31.4 dBm.

The Reader RF Power is set through the **Settings Page** as described on Page 10. Note that in no case may the power be set higher than 32.5 dBm.

Recommended Power Settings

Antenna Type	Short Cable	Long Cable
V740-HS02C	31.4 dBm	31.5dBm

Reader Installation

The following parts are provided with the Reader:

Part	Qty.	Part Number
V740 RFID Reader	1	V740-BA50C**-US
Power Supply	1	-
Operation Manual	1	This manual

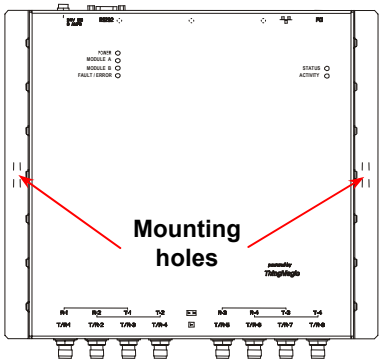
IMPORTANT: Be sure the user reads the section on *Declarations* to maintain compliance with FCC regulations.

Install the Reader

You can place the Reader on a shelf or mount it to a wall.

To mount the Reader on a wall:

1. Hold the Reader in its mounting location and mark the position of the mounting screws (2). Minimum screw size is #12 (M5).



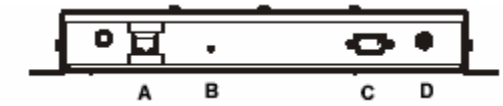
2. Drill holes for the screws and install wall anchors if required.
3. Insert the screws and tighten until almost flush with the wall.
4. Slip the Reader over the screws and slide down to lock the screws in the keyhole openings.
5. Tighten the screws.

Mechanical Loading - Mounting of the equipment in the rack should be such that a hazardous condition is not achieved due to uneven mechanical loading.

Install the Antennas

The antennas can be mounted directly to a variety of surfaces. Follow the installation instructions provided with the antennas.

Connect the Reader



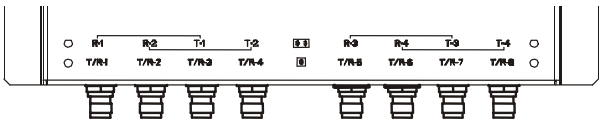
A = RJ-45 Ethernet port

B = Safe Mode button

C = RS232/RS485,GPIO(not available)

D = DC power input

One to four dual-antennas can be connected to the Reader, depending on the number of cards installed. Silk-screen markings on the Reader identify the cards installed.



1. Connect required UHF antennas to the ports on the Reader (see “Antenna Connection Option” on page 6).

   IMPORTANT: Connect antennas to the ports before applying power to the Reader. Any port not having an antenna connected to it will be disabled when the Reader is powered on.

2. Verify that all antennas are securely connected.
3. Connect the Reader to the network by plugging an Ethernet cable into the Ethernet port.

   or

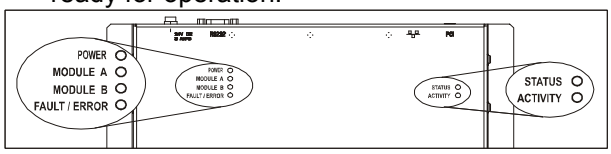
   Connect the Reader to a PC (personal computer) by plugging a crossover Ethernet cable into the Ethernet port.

   [If DHCP is to be used, then the network must be connected **before** powering up the Reader. If a DHCP server is not found the Reader will fall back to the IP address: “10.0.0.101”.]

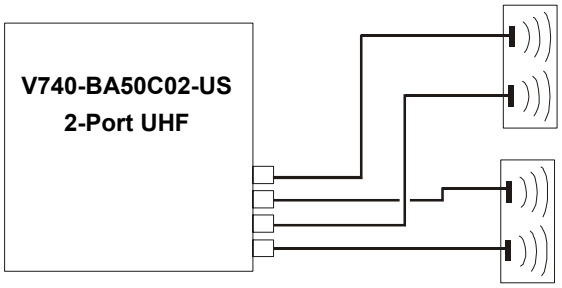
IMPORTANT: The Reader and the antennas are installed by only professionals at specific location and also they must be used at the separate distance of at least 21 cm (8.3in).

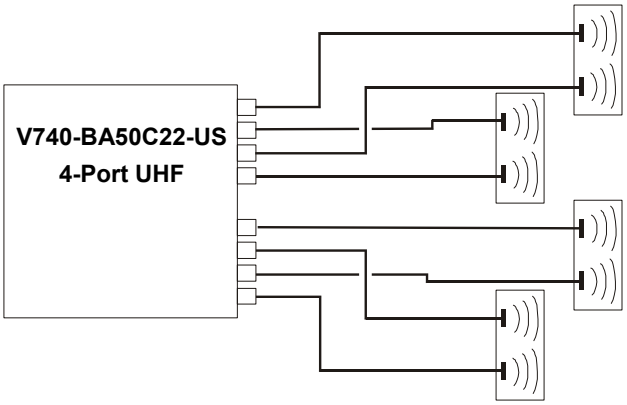
4. Plug the transformer provided with the Reader into the DC power input connector. Then connect the transformer to a power outlet.

   While the Reader is powering up, one green light will be on. After the Reader finishes its power-on self-test, approximately 30 seconds, the green light will pulse. The Reader is now ready for operation.



Antenna Connection Options





Reader Configuration

In some cases, the application software may provide support for Reader configuration. If so, follow the instructions provided with the application.

The following procedure describes how to configure the Reader directly from a network PC using the browser-based interface.

The Reader is shipped to use DHCP by default but will fall back to the following static network configuration if it is does not get a DHCP lease:

IP Address:	10.0.0.101
Subnet Mask:	255.255.255.0
Gateway:	10.0.0.1

You must know the IP address and subnet mask settings for the network environment in which the Reader will be running or you may use Apple's Rendezvous™ protocol (download Rendezvous™ from Apple's website) to browse to it.

1. Exit any Reader applications that are running on the network.

   IMPORTANT: Running another Reader application while using the browser-based interface may cause a Reader error. If this happens, reboot the Reader or restart the system using the browser-based interface.

2. Verify that the Reader is operational. All LED's should be out except for the green power LED which should be pulsing.

3. Start a Java-enabled web browser from any network-enabled PC. This PC must be configured with an IP address and subnet mask compatible with the Reader's settings. For example:

   IP address 10.0.0.10
   Subnet mask 255.255.255.0

4. Browse to…

   http://mercury4/ (dhcp name) or

   http://10.0.0.101

   The *V740 Reader/Writer* browser-based interface to the tag Reader is displayed.

5. Click the **Settings** link in the navigation menu. The Modify Settings page appears.
6. These setting apply to both the LAN interface and the wireless interface. If you wish to use DHCP select the DHCP? Yes radio button; otherwise, enter the required network settings in the IP Address, Subnet Mask, and Gateway fields. The fields will turn red if the gateway is not on the same subnet as the IP address. Then, click the Save Changes button.

   IMPORTANT: Do not disconnect power until the save process is complete.
7. Set the Reader RF power per instructions on page 4 to correspond to antenna and cable types.
8. Verify that the settings shown are correct. Then, restart the Reader by disconnecting the power cable and then reconnecting it (Restarting the Reader on page 10).

   It may take several seconds for the Reader to restart. If the IP address was changed, you must type the new address into the browser address field to communicate with the Reader.
9. Once the system restarts, click **Save Changes**. You are taken to the **Settings** page. Your changes will be saved and then applied. After the Reader reconfigures its network interfaces, it will automatically redirect you to its status page. There is no need to restart the Reader.

   IMPORTANT: Do not disconnect power while the Reader is saving its new configuration.

   The Reader is now ready to receive commands from the network.
10. Use the **Query** page of the browser-based interface to verify antenna operation.
11. Close the browser window. Start the Reader application on the network.

Reader Service

Using the Browser-Based Interface

The V740 Reader browser-based interface communicates directly with the RFID Reader. It includes several tools that enable you to monitor Reader performance, change Reader settings, and upgrade Reader firmware.

A navigation menu provides access to the following pages:

- **Status**—Displays current operational settings.
- **Query**—Allows the user to set frequency of operation, set antennas, set RF air interface protocols, and read tags.
- **Write**—Allows the user to write tags; this is only applicable to tags that are writeable.
- **Settings**—Allows the user to modify network settings.
- **Firmware**—This page can be used to upgrade the tag Reader with new firmware images supplied by OMRON.
- **Restart**—Allows the user to restart the Reader.
- **Diagnostics**—This page provides the current operating settings of the Reader.
- **Help**—This page provides information that is helpful in operating the tag Reader.

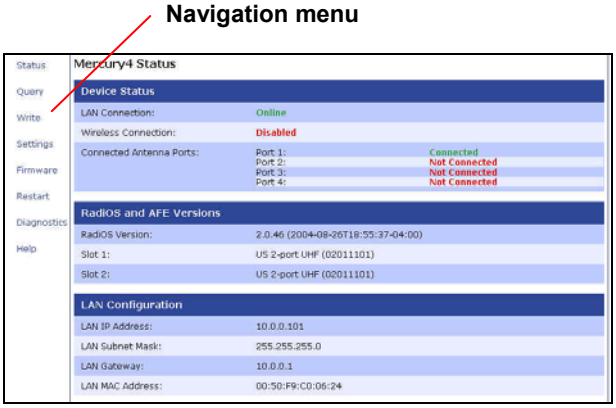
The browser-based interface can be run from any PC on the network. Care must be taken to configure the PC with an IP address and subnet mask compatible with the current operational settings of the Reader.

To start the browser-based interface:

1. Exit all Reader applications on the network.

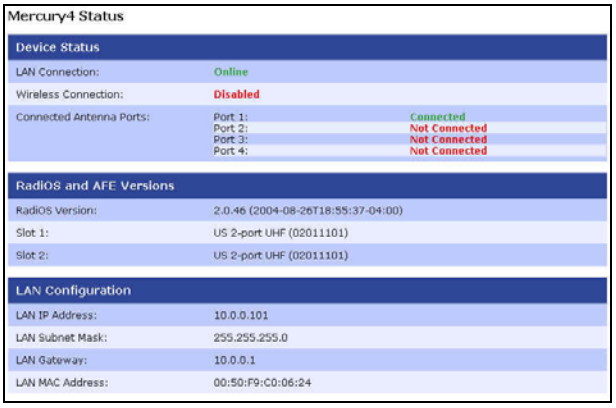
   IMPORTANT: Running another Reader application while using the browser-based interface may cause a Reader error. If this happens, reboot the Reader or restart it using the browser-based interface.
2. Start a Java-enabled web browser from any network-enabled PC.
3. Type the IP address of the Reader to which you want to communicate in the Address field of the browser or use Apple's Rendezvous™ protocol to browse to it.

4. A navigation menu and the **Current Operational Settings** page appear in the browser.



Status Page

The **Status** page shows the current settings of the Reader.



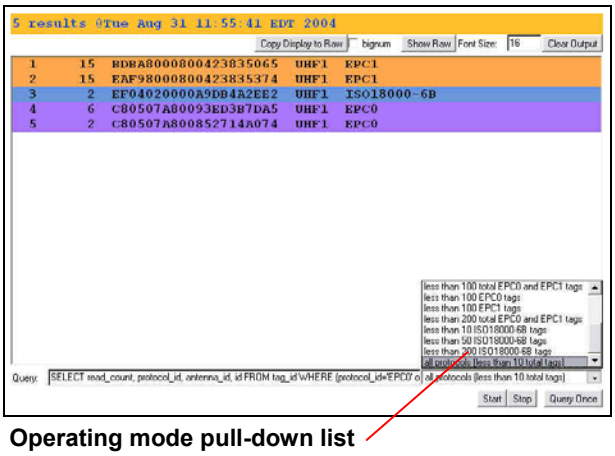
1. Click the **Status** link in the navigation menu to display the **Current Operational Settings** page.
2. Close the browser window if you are finished using the browser-based interface.

Query Page

Use the **Query** page to monitor Reader performance. The **Query** page is useful for verifying performance when installation is complete and for troubleshooting performance issues.

The Query field includes a drop-down list (at the bottom-right of the screen) that enables you to specify the operating mode. The operating mode specifies the tag protocols and antenna ports to be used in conjunction with the Query page.

Note: The selected settings DO NOT affect Reader performance associated with other applications.

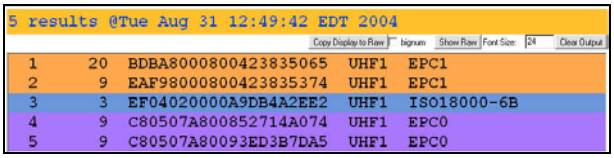


The following operating modes are available for use with the Query page:

Selection	Description
EPC1	CC915 protocol tags using both UHF antenna ports
CC915@UHF1	CC915 protocol tags using UHF port 1
CC915@UHF2	CC915 protocol tags using UHF port 2
ALL	All protocols using all ports

1. Click the **Query** link on the navigation menu. The Query page appears.
2. Select the operating mode from the pull-down list.
3. Click the **Start** button to begin reading tags.

   Tag data is displayed. Each entry shows sequential tag number, number of times tag was read, tag data, antenna, and protocol.

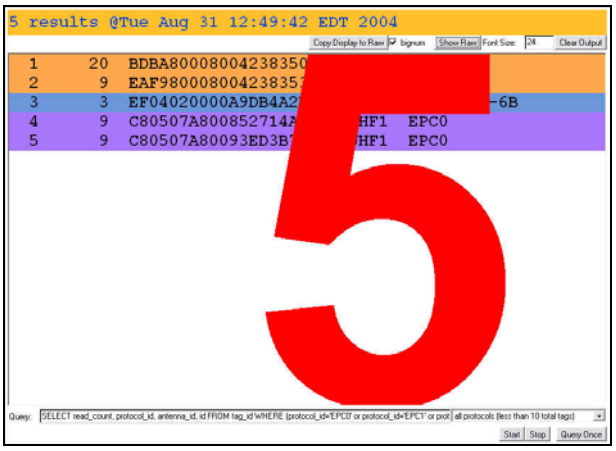


4. Click **Stop** to stop the tag search.

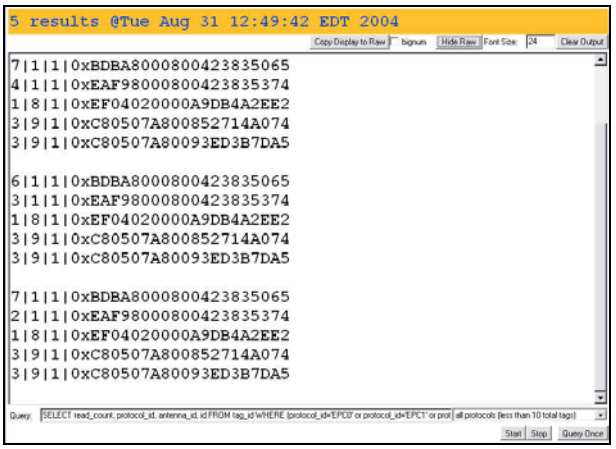
   IMPORTANT: You MUST stop the query before exiting the browser-based interface or the Reader will continue to poll antennas.

The Query page provides additional options that enable you to control the data that is gathered and how it is displayed:

- **Bignum** checkbox (when checked) displays the total number of unique tags read. The total is displayed in large red numbers directly over the tags read list.



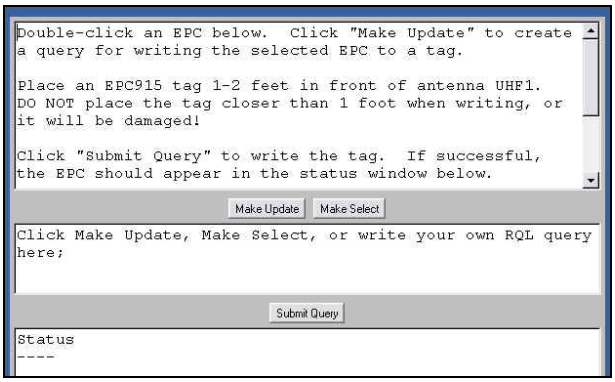
- **Show Raw** button displays raw tag data on the Query page. Each entry shows Reader, protocol, antenna, and tag data.



- **Hide Raw** button stops the display of raw tag data.
- **Clear Output** button clears the data displayed.
- **Query Once** button initiates a single search cycle after clicking **Start**.

Write Page

Use the Write page to replace the EPC data that is encoded on a 915 MHz EPC Class 1 tag.



Consider the following guidelines when writing to tags:

- Always place a tag 0.3–0.6m (1–2ft) from the antenna when writing data. The tag may be damaged if it is too close to the antenna.
- Only unlocked 915 MHz tags can be used. The write function is not supported for 13.56 MHz tag protocols.
- The data to be written must be exactly 16 hexadecimal characters (numerals from 0–9 and letters from A–F).
- Always place only one tag in the antenna's field when writing. If multiple tags are present, they will all be encoded with the same EPC data.
- Use the antenna connected to UHF1.

To write data to a tag:

1. Click the **Write** link on the navigation menu. The Write page appears.
2. In the top pane, type or paste the 16-character hexadecimal data to be written to the tag.
3. Highlight the hexadecimal data.
4. Click the **Make Update** button. A query designed to write the highlighted data to the tag appears in the center pane.
5. Place the tag 0.3–0.6m (1–2ft) from the antenna connected to UHF1.

   Verify that no other tags are in the antenna's field.
6. Click the **Submit Query** button to write the data. If the write was successful, the new tag data appears in the bottom pane.

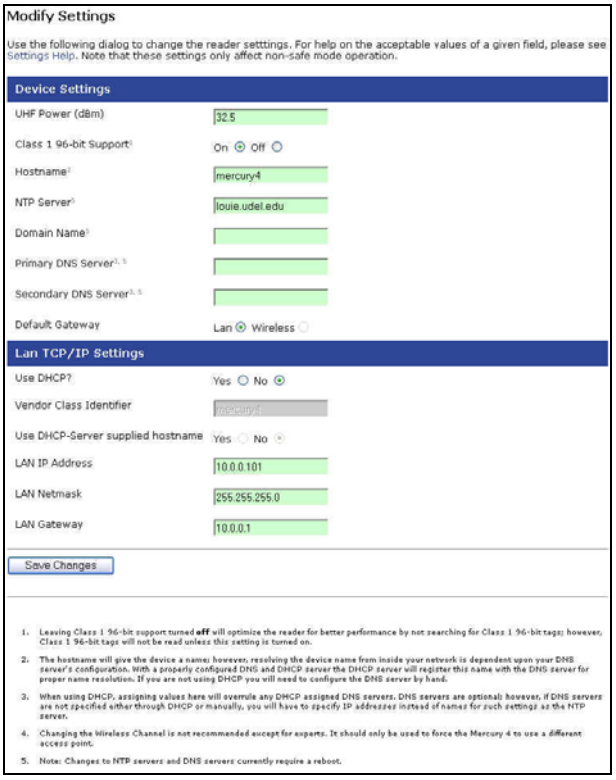
To read data from a tag:

1. Display the Write page (click the Write link on the navigation menu).

2. Click the Make Select button. A query designed to read data from the antenna connected to UHF1 appears in the center pane.
3. Place the tag to be read within the detection zone of the antenna.
4. Click the Submit Query button to read tag data. Query results appear in the bottom pane.

Settings Page

Use the **Modify Settings** page to change network settings.



1. Click the **Settings** link on the navigation menu. The Modify Settings page appears.
2. Enter the required settings.
3. Click the **Save** button to save the new settings.

   IMPORTANT: Do not disconnect power until the save process is complete.

   The new settings DO NOT take effect until the Reader is restarted by rebooting the Reader (see Restarting the Reader on page 12).

Instructions for Modifying the Settings

Changing these parameters changes the Readers settings used on startup. Both radio settings and network settings can be modified. Care must be taken to use correct values or you might be unable to connect the Reader without restarting into safe mode.

Static network settings are ignored when in DHCP mode, and DHCP related settings are ignored when in static IP mode. Please note that your network needs to have properly configured DNS servers if you wish to connect to the Reader via its hostname. Usually when using DHCP, the DHCP server will add the hostname to the DNS server's database.

Device Settings	
UHF Power (dBm)	UHF Output power in dBm. This setting must be adjusted carefully to comply with FCC regulations.
Class 1 96-bit Support	Radio button that enables 96-bit tag support. To optimize the Reader keep this setting turned off unless it is needed.
Hostname	Name of the device
NTP Server	Server or servers to use for network time protocol
Domain Name	Network domain name
Primary DNS Server	Primary DNS server
Secondary DNS Server	Secondary DNS server
Default Gateway	Radio button to select the default interface for network communications.
LAN TCP/IP Settings	
Use DHCP?	Radio button that sets the Reader to use DHCP.
Vendor Class Identifier	Extra DHCP parameter for integration and customization.
Use DHCP Server supplied hostname	Set this to **yes** to allow the DHCP server to assign the Reader a hostname.
LAN IP Address	The IP address to use when not using DHCP. It is specified in dotted-quad notation. The default value is 10.0.0.101.
LAN Gateway	When not using DHCP this setting specifies the default gateway to use. It is specified in dotted-quad notation. The default value is 10.0.0.1
LAN Netmask	TCP/IP netmask to use. The default value is 255.255.255.0.

Firmware Upgrade Page

1. Click the **Firmware** link on the navigation menu. The **Firmware Upgrade** page appears.
2. Place the cursor in the Filename field and type the complete network pathname of the firmware file or click the **Browse** button to locate the new firmware file.
3. Click the **Upgrade** button to download the new firmware to the Reader.

   The status frame at the bottom of the page displays the progress of the upgrade if the web browser supports automatic page reload. Click the **Refresh** button to update the status bar if the web browser does not support automatic page reload.

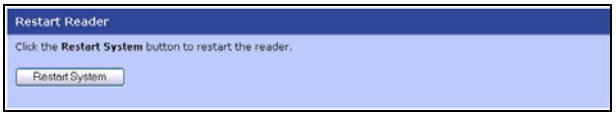
   Downloaded firmware IS NOT implemented until the Reader is restarted.

   If an error occurs during the firmware upgrade, use Safe Mode to recover.

Restart Page

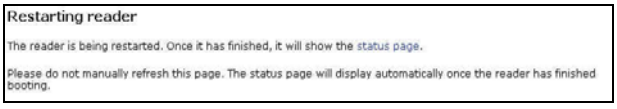
Use the Restart page to restart the Reader.

1. Click the Restart link on the navigation menu; The Restart Reader page appears.



2. To restart the Reader, click the **Restart System** button. The following dialog boa appears.

3. Click **OK**. The following message appears and remains on the screen until the Reader restarts. Then the Status page appears.

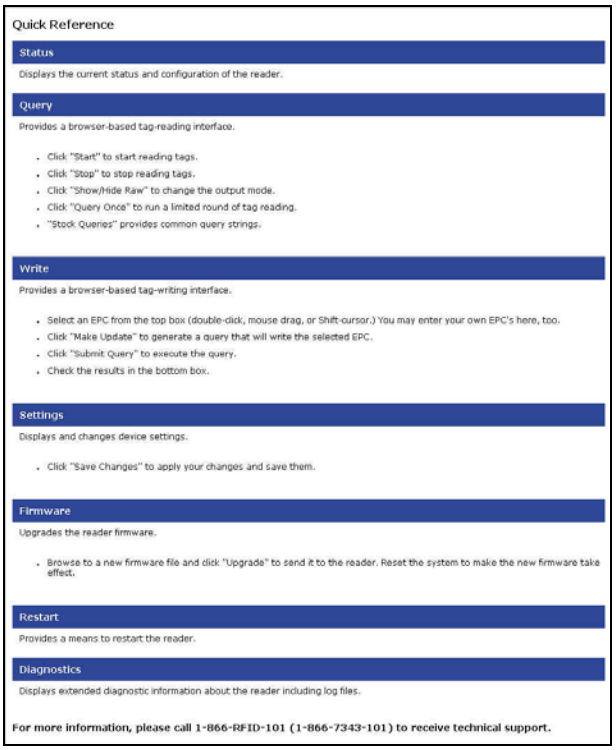


Diagnostics Page

The diagnostics page provides a wealth of information, including the current settings of the Reader, comprehensive version information, and current status of network interfaces.

Help Page

Use the Help page to view descriptions of system operations.



Restarting the Reader

Use this procedure to recover from a Reader error.

1. Click the restart link on the navigation menu.
2. Click the **restart** button and the **OK** button on the confirmation dialog.

   Wait for at least 60 seconds for the Reader to boot up. The Power/Heartbeat LED is solid green while the Reader boots. When the LED begins blinking, the boot process is complete.

Using Safe Mode

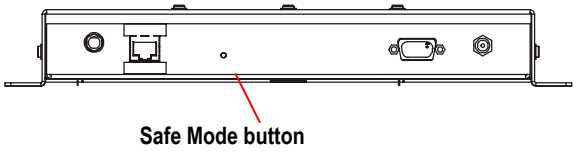
Use the Safe Mode button on the Reader connector panel to recover from errors that disable the Reader.

Safe mode operation restores factory default settings as follows:

Firmware Version: ..... factory installed version
UHF (915 MHz) RF Transmit Power:.....32.5
IP Address:.....DHCP
Hostname: V740

Although the browser-based interface pages are displayed in red when operating in Safe mode, the Reader is fully functional. In most cases, the Reader will need to be reconfigured for operation with the Reader application after starting in Safe mode.

1. Disconnect power from the Reader.
2. Depress and hold the Safe Mode button, using a nonconductive object, while restoring power to the Reader. Keep the Safe Mode button depressed until the Reader boots completely (the green Power/Heartbeat LED blinks).



3. Factory-default settings are restored.
4. Use the browser-based interface to configure the Reader for use with your system.

   This PC must be configured with an IP address and subnet mask compatible with the Reader default settings. For example: IP address 10.0.0.10, net mask 255.255.255.0.

5. Click the **Settings** link on the navigation menu and verify the new settings.
6. Restart the Reader with the new settings. Once the restart is complete, the Reader is no longer in Safe Mode.

Specifications

Electrical

Reader

UHF operating frequency 902–928MHz
Input voltage 24Vdc, 2.0A

Separate Power Supply

Input voltage ..... Nominal 100–240Vac, 50/60Hz
AC line current ..... Nominal 0.5A at 120V
Output voltage ..... Nominal 24Vdc, 2.5A peak
Certified limited power source
Class 2

Environmental

Operating temperature: ... 0° to 40°C (32° to 104°F)
Relative humidity: ..... 0 to 90% non-condensing

Mechanical

Reader

Length 26.5cm (10.4in)
Width 26.6cm (10.4in)
Width (with mounting bracket) 30.5cm (12in)
Depth 3.8cm (1.5in)
Weight ..... 1.4kg (3 lbs)

Supported Tag Protocols

915 MHz ..... EPC Class 1
EPC Class 0
ISO 18000-6B

OMRON

V740
RFID Reader Query Protocol

Reference Guide

This chapter lays the groundwork for the communication protocol between client software running on a remote computer and V740 RFID Readers. The client software can be any kind of database system, enterprise software, or user software.

In this chapter, we discuss the underlying transport protocol used and present the initial communication protocol RQL. This protocol is loosely based on the SQL language with extensions for a better notion of time. This protocol was designed for rapid prototyping of applications, where a full query to the Reader can be encapsulated in a single line of ASCII text. A simple polling mechanism exists for automatically receiving tag events and for testing, a connection can be mode from a standard telnet client.

Transport Protocol

In the current implementation, TCP/IP is used as the transport protocol. TCP is a connection-oriented protocol that provides a reliable, in-order data transport layer with end-to-end checksums and flow control.

TCP Connection Setup and Teardown

A *session* between client software and the Reader consists of *connection setup*, *data transactions*, and *connection teardown*.

At present, all connections are initiated *only by the client software*. If, for example, the Reader is configured to automatically forward events and/or data to the client software but the client software has not established a connection, then no attempt is made by the Reader to contact the client software to establish a connection. Furthermore, if an extant connection terminates unexpectedly, the Reader will not attempt to contact the client software to re-establish a connection. *All responsibility for opening, maintaining, and closing the connection during a session rests with client software*.

The client software sets up a TCP socket connection on Reader port 8080. After connecting successfully, communication between the client software and the Reader can proceed as described below. Once the client software has determined that communication has concluded, the connection must be terminated at the TCP level. In order to prevent synchronization issues, *each Reader will support only one TCP connection*.

Other transport protocols may be used to communicate between the client software and its subjugate Readers. The application-level protocol discussed below is neutral with respect to the transport layer.

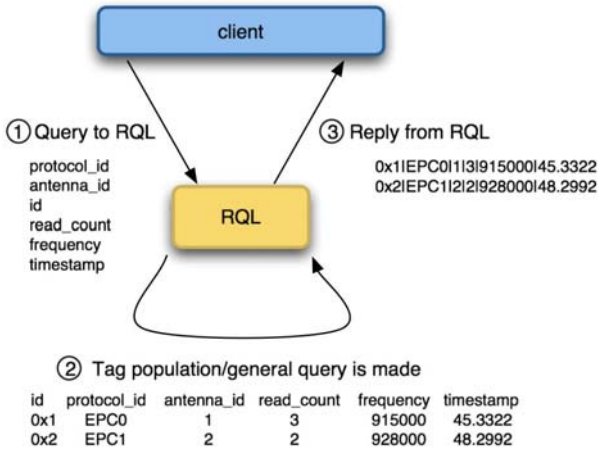
Event/Query Protocol

The client software can acquire data from the Readers in two modes: (a) by requesting specific data or (b) automatically receive events in another mode. The two modes are discussed in further detail in the following subsections.

In order to keep the protocol light but comprehensive, we specify a small set of commands that allow the client software to fully configure the Readers and exploit their capabilities.

This minimal set of commands includes the ability to request reads based on several relevant criteria (for example, group reads, range reads, reads by prefix, and so on). The ability to reset the Reader database and other control capabilities are also provided for.

Figure 1 Control flow of RQL



Client Software Requests/Functionality

The client software is able to make the following requests of a Reader:

- Read IDs of all tags within range of all antennas.
- Read IDs of all tags within range of a given antenna.
- Read IDs of all tags within a certain subset of tag IDs within range of all antennas.
- Read IDs of all tags within a certain subset of tag IDs within range of a specific antenna.
- Read Individual tag IDs within range of a certain antenna or all antennas.
- Read only the Ids of tags communicating a given RF communication protocol.
- Return the number of times a given tag was read per query.
- Read IDs from a variety of tag protocols
- Write IDs to a tag from a variety protocols as they are supported.
- Read data from a tag from a variety of protocols as they are supported.

General Observations, Commands, and Syntax

We note that a Reader behaves very much like database wherein each individual tag represents an entry in the database with a given set of attributes. Due to memory constraints of the Reader, the system will remove entries from the database as they are queried. The syntax for querying against this database is derived from SQL syntax.

In the simplest case, the client software explicitly requests data by polling the Readers. The request protocol is implemented in such a way that the client software specifies:

What information it needs.

- What subset of tags the Reader should consider.
- Which read constraints should be applied.

Example commands:

- `SELECT id FROM tag_id WHERE id=0xF00D123456789ABCB0DE AND antenna_id=1;`

  Would return a tag only if its tag ID was `0xF00D123456789ABCB0DE`.

- `SELECT id FROM tag_id WHERE antenna_id=3 OR antenna_id=4 SET time_out=1000;`

  Would return a tag only if the antenna ID was 3 or 4 and will search for at least 1000ms.

Extended RQL Command Structure supported by the V740

Extended Command Set for Data and Write, and Lock operations

ID Read: Identify tags, including anti-collision.

ID Write/Lock: Initialize tag ID, prevent further changes

Kill, Password: Disable tag, control access to disable function

Data Read/Write/Lock: Access tag data

(See Table RQL-1 below)

Table RQL-1

		Parameters/Constraints	RQL Query	Meaning
ID	Read	()	SELECT id FROM tag_id	Reads a tag's id
	Write	(new_id)	UPDATE tag_id SET id=0x1234	Gives a tag a new id
	Lock	(locked)	UPDATE tag_id SET locked=1	Locks a tag
Kill		(id, password, killed)	UPDATE tag_id SET killed=1 WHERE id=0x1234 AND password=0x1234	Kills a tag
Password		(new_password)	UPDATE tag_id SET password=0x1234	Sets the password of a tag
Data	Read	(id, blocknum)	SELECT data FROM tag_data WHERE id=0x1234 AND blocknum=12	Reads raw data from a matching tag
	Write	(id, new_value, blocknum)	UPDATE tag_data SET data=0x1234 WHERE id=0x1234 AND blocknum=12	Writes data to a specific tag and memory block
	Lock	(id, addr, blocknum)	UPDATE tag_data SET locked=1 WHERE id=0x1234 AND blocknum=12	Locks a block of memory

With the exception of the 'ID Read' command, all commands are protocol and antenna specific and can only be used with a single protocol at a time and with a single antenna at a time. Hence all queries with the exception 'ID Read' need to be constraint to one protocol and one antenna using, for example

```
WHERE protocol_id='CC915' and
antenna_id=1
```

A complete example of a complete 'ID Write' query would be

```
UPDATE tag_id SET
id=0x0123456789ABCDEF WHERE
protocol_id='CC915' AND antenna_id=1.
```

'ID Read' (enumerate tags) is, by definition, a multi-target command, since it determines what the individual targets are in the first place.

There are some special cases to the single-target rule. For example, ID Write is semantically tricky – what does it mean to target a tag if its target ID is going to be changing? In the current state of the art, most protocols do not support addressed ID writes (ID write targets all tag IDs) or disallow tag ID changes entirely.

RQL Table Schema

As was mentioned before, RQL is derived from the SQL language, which allows the user to define arbitrary tables. RQL has predefined tables according to the schema below. NOTE: Tag_id and Tad_data values are case-sensitive and are all lowercase only.

Read/Write	Tag_id	Type
R	protocol	Int
R	antenna	Int
R/W	id	Hex String
W	killed	Int
W	password	Hex String
R/W	locked	Int
R	frequency	Int
R	dspmicros	Int
R	timestamp	string

Read/Write	Tag_data	Type
R	id	Hex String
R/W	blocknum	Int
R/W	data	Hex String
R	locked	Int

Read/Write	Tag_id	Type
R	version	String
R	supported_protocols	String

Read/Write	Settings	Type
R	current_time	String

Detailed Command Structure

Select, Where, Set

The SELECT command is for querying the tag population of the Reader as well as static variables such as firmware version and supported protocols. The structure of a SELECT command is as follows:

SELECT *select_list* FROM *table_expression* [where_specification] [set_specification];

A `where_specification` is entered as:

WHERE *boolean_expr*

`boolean_expr` can consist of any expression which evaluates to a boolean value. In many cases, this expression will be:

expr binary_operator expr

or

unary_operator expr

where *binary_operator* can be one of =, <, <=, >, >= , <>, AND, or OR, and *unary_operator* can be "NOT". Parentheses may also be used to create associations of subexpressions. In the presence of a WHERE clause, SELECT will not return any rows for which the WHERE condition does not evaluate to TRUE.

A `set_specification` is entered as:

SET *expression*

In the following we provide some more examples for the usage of `SELECT, WHERE, SET`:

- To query a specific tag, given its *ePC* code, one can specify a specific tag with id as a hexadecimal number*:*

```
SELECT id FROM tag_id WHERE id=id AND
antenna_id=antenna_id;

SELECT id FROM tag_id WHERE id=id SET
time_out=500;
```

  The Reader returns the tag if the tag is present followed by an empty event ('\n') or an empty

event ('\n') if tags matching the WHERE clause are not present. The first version requests a read from a specific antenna, while the second does not. The second command imposes a time out constraint of 500ms; i.e., the Reader stops reading and returns all collected data after 500ms. The order in which specifying arguments are used is irrelevant. The default timeout if none is specified is 250ms.

Any previous statement's use of the `time_out` **variable will change the default timeout until a** `RESET` **is asserted**. It is important to always use a timeout in specifying a query to achieve optimal performance for a given application. This will be discussed later in section

- To query a specific sub class of tags, given a range of *ePC*s:

```
SELECT id FROM tag_id WHERE
tag_id>min_tag_id AND
tag_id<max_tag_id SET timeout=1000;
```

The Reader returns the *ePC*s for all the present tags between *id_min* and *id_max*, which are hexadecimal values.

- To query all tags:

```
SELECT id FROM tag_id SET
timeout=2500;

SELECT id FROM tag_id WHERE
antenna_id=1 SET timeout=2500;
```

The Reader returns all the tags it can find. The second version requests a read from a specific antenna, while the first does not.

- The client software specifies which information it requires in the `select_list` field of the SELECT command:

```
SELECT id, antenna_id FROM tag_id SET
timeout=2500;

SELECT frequency, timestamp, id,
antenna_id FROM tag_id SET
time_out=1000;
```

Returns the id and antenna_id of every tag in the field in the first example and the frequency and time the tag was read at (seconds from the unix epoch, Jan 1, 1970) in the second example.

Update, Where

The UPDATE command is to write new data into a table. This can be used to write a new tag_id or sleep the Reader for a specified amount of time. The structure of an UPDATE command is as follows:

```
UPDATE table SET col=expression [,
…] [WHERE wherelist];
```

`table` and `col` entries are provided in Table 1.

The WHERE clause is specified in the same manner as in the SELECT call above. In the following we provide some examples for usage of `UPDATE`:

- To write data for a 64-bit ePC tag id with a specified lock code, password and block_number:

```
UPDATE tag_data SET
data=0xFEDCBA9876543210,
block_number=0, lock_code=0xef,
password=0xcd WHERE protocol='CC915'
AND antenna_id=1;
```

The Reader returns the tag_id if the write operation was successful or "`Error 128: Error encountered while attempting to process tags\n\n`" in safe mode, and "`Error 128: Error encountered while attempting to process tags\n\n`" in single query mode otherwise.

- To write for a specified amount of time:

```
UPDATE tag_data SET
data=0xFEDCBA9876543210,
block_number=1, lock_code=0xef,
password=0xcd, time_out=250 WHERE
protocol='CC915' AND antenna_id=1;
```

Would try to write the tag id for 250ms.

- To sleep the Reader for a specified amount of time:

```
UPDATE sleep SET time_out=500;
```

Would turn off the RF interface for 500ms. This can be useful for scheduling Readers and reducing interference.

- Other Updates: kill, locking, password

```
UPDATE tag_id SET killed=1,
id=0x112233445566778899AABBCC,passwor
d=0x88 WHERE protocol_id='EPC1' AND
antenna_id=4;

UPDATE tag_id SET locked=1,
id=0x0123456789ABCDEF WHERE
protocol_id='EPC1' AND antenna_id=4;

UPDATE tag_id SET password=0x88,
id=0x0123456789ABCDEF WHERE
protocol_id='EPC1' AND antenna_id=4;
```

Cursors

The client software has the ability to declare cursors (saved queries), which it can then use to request data repeatedly using the OPEN or the AUTO_MODE command. A maximum of 16 cursors can be defined.

To create a cursor:

```
DECLARE cursorname
CURSOR FOR query
```

cursorname — an arbitrary string.

query — a SQL query (SELECT/UPDATE statement), as defined above.

Example:

```
DECLARE cursor1 CURSOR FOR SELECT id,
antenna_id FROM tag_id;

DECLARE cursor2 CURSOR FOR UPDATE
tag_data SET data=0xFEDCBA9876543210;
```

One of the advantages of multiple cursors is that it allows one to specify unequal times for different protocols. To give 900 ms to EPC1 and 300 ms to EPC0 in a 1200 ms search do the following:

```
DECLARE c1 CURSOR FOR SELECT
read_count, protocol_id, antenna_id,
id FROM tag_id WHERE (antenna_id = 1
OR antenna_id = 2 OR antenna_id = 4)
AND protocol_id='CC915' SET
time_out=900;

DECLARE c2 CURSOR FOR SELECT
read_count, protocol_id, antenna_id,
id FROM tag_id WHERE(antenna_id = 1
OR antenna_id = 3 OR antenna_id = 4)
AND protocol_id='EPC0' SET
time_out=300;

SET AUTO c1,c2 = on;
```

Fetch

To execute the saved query associated with a cursor, the client software sends the FETCH command.

```
FETCH cursorlist;
```

which performs all actions appropriate to the declared query and sends the result back.

Example:

```
FETCH cursor1, cursor2;
```

Auto Mode

In addition to executing a cursor once with the FETCH command, the client software may also switch the Reader into Auto Mode, causing it to repeatedly execute a cursor indefinitely.

```
SET auto cursorlist = ON, repeat =
interval;
```

For example,

```
DECLARE c CURSOR FOR SELECT id,
antenna_id FROM tag_id SET
time_out=250;

SET auto c = ON, repeat = 500;
```

Every 500 milliseconds, the Reader spends 250 milliseconds querying for tags. The remaining 250 milliseconds are spent with RF off. This syntax can be used for controlling the duty cycle of the Reader. For full Reader utilization, ensure that the value of time_out is no less than the value of *repeat*.

The repeated queries can be terminated by sending the command:

```
SET auto = OFF;
```

No other command can be used while Auto Mode is active.

Close

To close a cursor and free its resources (only 16 cursors may be defined simultaneously). Only one cursor can be freed at a time. The client software issues the command:

```
CLOSE cursorname;
```

Reset

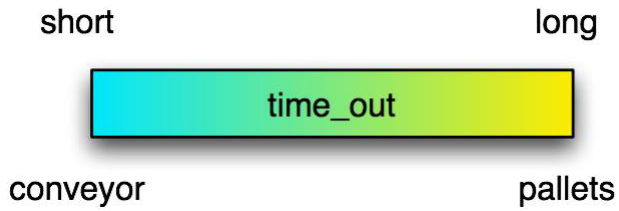
To reset the Reader RQL server, for example, if the RQL state is undefined or questionable, use:

```
RESET;
```

The command returns the RQL daemon to its initial state; that is, no cursors are defined and no data has been read from the field.

Timeout

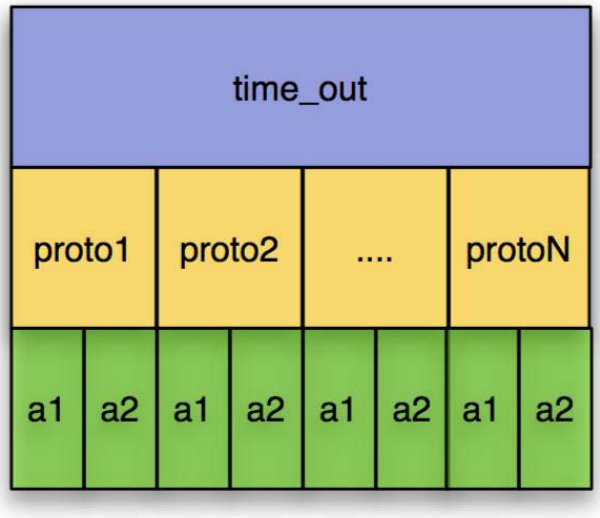
The client software can impose a time limit on a read operation, requesting the Reader to search only for a limited time (specified in milliseconds). The Reader may fail to detect some tags if insufficient time is allocated to the search operation. The time_out is the parameter used for changing the function of a Reader and indicates assumptions about the role of the Reader.



In general, a large time_out should be used for pallets (>2s), and short time_outs should be used for conveyor belts (<100ms).

```
SELECT id FROM tag_id SET
time_out=1000;
```

The constraints on the scheduler in the V740 for the time_out are shown below. Time is equally divided among the specified protocols, and then divided among the antennas.



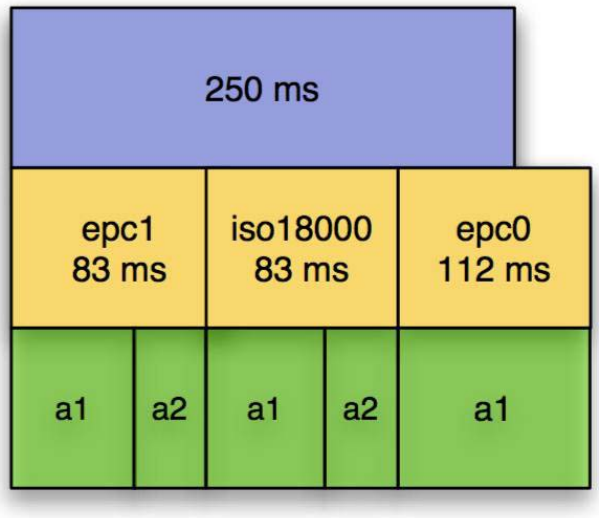
For all protocols except EPC0, the antenna arbitration algorithm is optimized for the maximizing the read rate of the tags in the field. For EPC0, at this time, each antenna will be arbitrated 112ms of search time. Thus, time division for antennas within a protocol cannot be specified. It is important in specifying a search to specify the protocols one is searching on, or else the Reader will spend time searching for protocols one is not interested in. For specifying the time to search over multiple protocols for a single query, it is important to keep in mind that the time_out parameter should be specified as the worst case of the multiple protocols.

minimum time_out =
max{num_epc0*epc0_time_per_tag,num_epc1*epc1_time_per_tag,num_iso*num_iso_time_per_tag,..}x # protocols x # antennas (ms)

e.g. if 40 EPC0 tags takes 1.4 ms per tag and 10 EPC1 takes 16 ms per tag on average. With two antennas:

minimum time_out =
2 x 2 x max{40*1.4,10*16} = 640 ms.

As another example, if the goal is to search on EPC1 and EPC0 on antennas 1, 2, or 4 for strong 20 tags on each protocol. The query specified is `'SELECT read_count, protocol_id, antenna_id, id FROM tag_id WHERE antenna_id = 1 OR antenna_id = 2 OR antenna_id = 4'`

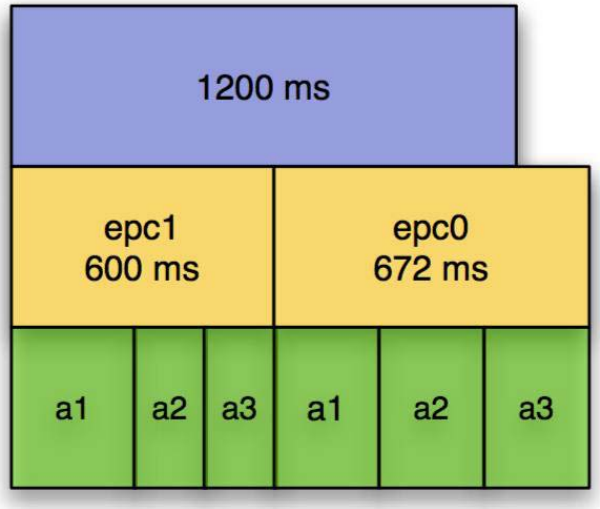


V740 will search 3 protocols for 250 ms:

EPC0, EPC1, and ISO18000-6b will each get a 83.3ms slot. This will allow all 20 EPC0 tags to be read, but not all EPC1 tags.

If the EPC0 tags are present only on the 4th antenna, the Reader will never arbitrate time to this antenna. A better query would be:

```
SELECT read_count, protocol_id, antenna_id,
id FROM tag_id WHERE (antenna_id = 1 OR
antenna_id = 2 OR antenna_id = 4) AND
(protocol_id='CC915' OR protocol_id='EPC0')
SET time_out=1200
```



Both EPC0 and EPC1 will get 600 ms:
each antenna for EPC0 will get 200 ms (above 112ms) should read all 20 EPC0 and 20 EPC1.

Use of RQL for Scheduled Reads

The V740 uses the Network Time Protocol as a means to establish absolute time on the Reader. With that capability in place the Reader is enabled to execute tag operations that have been scheduled relative to absolute time. Here is how it works.

First the user declares a cursor, or a set of cursors, in a way similar to how to you use cursors in auto mode.

To run the query once at a specific time you use a command of the form:

```
SET trigger_time <cursor list> = '<time string>';
```

To run the query in auto mode over a given interval:

```
SET auto_time <cursor list> = '<start time>';
```

or

```
SET auto_time <cursor list> = '<start time>/<stop time>';
```

The first form here starts the auto mode at a given time, and then just continues until you stop it, the same way you'd stop normal auto mode.

The second form runs during the specified interval.

The cursor lists are the normal form of either 1 cursor "cursor1" or a list of cursors, "cursor1, cursor2, cursor3..."

The start and stop time are specified in ISO8601 time strings, of the form

```
YYYY-MM-DDTHH:mm:SS.DDDDZZZZZ
```

Where YYYY is the year, MM is the month, DD is the day, HH is the hour, mm is the minute, SS is the second, and DDDD is the fraction of a second, and ZZZZZZ is the time zone. The seconds and fractions of a second are both optional (but if you want fractions of a second, you have to have seconds as well). The time zone can either be specified as GMT or Zulu time by using a 'Z' or it can be an offset from GMT using +HH:MM or -HH:MM. For us, in Eastern time, that would be -05:00.

Some examples:

```
DECLARE c1 CURSOR FOR SELECT id FROM tag_id WHERE antenna_id=1 AND protocol_id='CC915';


DECLARE c2 CURSOR FOR SELECT id FROM tag_id WHERE antenna_id=2 AND protocol_id='ISO15693';
```

To run c1 once on February 14th 2004 at 18:54:50 GMT:

```
SET trigger_time c1 = '2004-02-14T18:54:50Z';
```

To run c1 and c2 both for 10 seconds starting at 2004-01-20 at 15:37 in Eastern Standard Time:

```
SET auto_time c1, c2 = '2004-01-20T15:37-05:00/2004-01-20T15:37:10-05:00';
```

Errors

If the Reader is unable to execute a command issued by the Client Software, the Reader issues an error message, which has the basic form:

```
ERROR error_code: string
```

where `error_code` is an integer. Error codes are documented in Table 2.

For example:

```
DECLARE query1 CURSOR FOR SELECT id FROM tag_id;

FETCH query2;
```

Would result in the error message:

```
ERROR 1 FETCH: Cursor does not exist
```

Table 2: Error code

(-100)	ERROR_INVALID_ARGUMENTS	No protocol specified
(-100)	ERROR_INVALID_ARGUMENTS	Too many protocols specified
(-100)	ERROR_INVALID_ARGUMENTS	No antenna specified
(-100)	ERROR_INVALID_ARGUMENTS	Too many antennas specified
(-100)	ERROR_INVALID_ARGUMENTS	No antenna specified
(-100)	ERROR_INVALID_ARGUMENTS	Unknown table
(-100)	ERROR_INVALID_ARGUMENTS	Cursor already exists
(-100)	ERROR_INVALID_ARGUMENTS	Unknown setting
(-100)	ERROR_INVALID_ARGUMENTS	Cursor does not exist
(-100)	ERROR_INVALID_ARGUMENTS	Unknown field
(-100)	ERROR_INVALID_ARGUMENTS	Invalid set clause entry
(-100)	ERROR_INVALID_ARGUMENTS	DELETE: Cursor does not exist
(-100)	ERROR_INVALID_ARGUMENTS	Invalid set clause entry
(-101)	ERROR_INVALID_DATA	Unknown setting
(-101)	ERROR_INVALID_DATA	Time is invalid
(-101)	ERROR_INVALID_DATA	Unknown protocol ID
(-101)	ERROR_INVALID_DATA	Invalid command in current mode
(-101)	ERROR_INVALID_DATA	Time is invalid
(-102)	ERROR_REMOTE	Error setting ping threshold\n
(-102)	ERROR_REMOTE	Error setting saved ping threshold
(-102)	ERROR_REMOTE	Error setting saved IP address
(-102)	ERROR_REMOTE	Error setting saved gateway
(-102)	ERROR_REMOTE	Error setting saved netmask
(-102)	ERROR_REMOTE	Error setting firmware version
(-102)	ERROR_REMOTE	Error setting safemode version
(-102)	ERROR_REMOTE	Error setting OS version
(-102)	ERROR_REMOTE	Error setting supported protocols
(-102)	ERROR_REMOTE	Invalid antenna(None of the requested antenna_ids exist in this installation)
(-102)	ERROR_REMOTE	Antenna not connected(None of the requested antenna_ids have an antenna attached)
(-102)	ERROR_REMOTE	Error performing query
(-102)	ERROR_REMOTE	Error getting operation state
(-102)	ERROR_REMOTE	Invalid antenna(antenna_id does not exist in this installation)
(-102)	ERROR_REMOTE	Antenna not connected(antenna_id does not have an antenna attached)
(-128)	ERROR_UNKNOWN	Tag data access failed
(-128)	ERROR_UNKNOWN	Error getting entry
(-128)	ERROR_UNKNOWN	Error getting ip address entry
(-128)	ERROR_UNKNOWN	Error getting netmask entry
(-128)	ERROR_UNKNOWN	Error getting gateway entry

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Protocol Specific Functionality and Parameter Settings

While the standard ID_read and anti-collision searches are supported by practically all offered protocols, hence no protocol-specific information is required to issue and RQL search. More specific commands, such as data_read and data_write require protocol specific information when formatting the query and interpreting the results. The tables below provide that information.

915 MHz EPC Class 1

		Parameters / Constraints	**Return Value (String)**	**Example**
ID	Read	()	80 bit (64 bit ID and 16 bit CRC, hex format) or 112 bit (96 bit ID and 16 bit CRC)	SELECT id FROM tag_id WHERE protocol_id='CC915'
	Write	**id:** 64 bits or 80 bits (hex) **password:** 8 bits (hex)	error_code OR new_id	UPDATE tag_id SET id=0x1234567890ABCDEF WHERE protocol_id='CC915' AND antenna_id=1
	Lock	()	error_code OR success_notification	UPDATE tag_id SET locked=1 WHERE protocol_id='CC915' AND antenna_id=1
Kill		**id:** 64 bits (hex) **password:** 8 bits (hex)	error_code OR success_notification	UPDATE tag_id SET killed=1 WHERE id=0x1234567890ABCDEF AND password=0x12 AND protocol_id='CC915' AND antenna_id=1
Password		**New_password:** 8 bit (hex)	error_code OR success_notification	UPDATE tag_id SET password=0x12 WHERE protocol_id='CC915' AND antenna_id=1
Data	Read	N/A		
	Write	N/A		
	Lock	N/A		

915 MHz EPC Class 0

		Parameters / Constraints	Return Value (String)	Example
ID	Read	()	80 bit (64 bit ID and 16 bit CRC, hex format) or 112 bit (96 bit ID and 16 bit CRC)	SELECT id FROM tag_id WHERE protocol_id='EPC0'
	Write	N/A		
	Lock	N/A		
Kill		Id: 64 bits or 80 bits (hex) password: 8 bits (hex)	error_code OR success_notification	UPDATE tag_id SET killed=1 WHERE id=0x1234567890ABCDEF AND password=0x12 AND protocol_id='EPC0' AND antenna_id=1
Password		New_password: 8 bit (hex)	error_code OR success_notification	UPDATE tag_id SET password=0x12 WHERE protocol_id='EPC0' AND antenna_id=1
Data	Read	N/A		
	Write	N/A		
	Lock	N/A		

915 MHz ISO18000-6B

		Parameters / Constraints	Return Value (String)	Example
ID	Read	()	80 bit (64 bit ID and 16 bit CRC, hex)	SELECT id FROM tag_id WHERE protocol_id='ISO18000-6B'
	Write	N/A		
	Lock	N/A		
Kill		N/A		
Password		N/A		
Data	Read	id: 64 bit (hex) addr: integer [0…223]	8 bit (hex)	SELECT data FROM tag_data WHERE id=0x1234567890ABCDEF AND blocknum=12 AND protocol_id='ISO18000-6B' AND antenna_id=1
	Write	id: 64 bit (hex) addr: integer [8…223] new_value: 8 bit (hex)	error_code OR success_notification	UPDATE tag_data SET data=0x12 WHERE id=0x1234567890ABCDEF AND blocknum=12 AND protocol_id='ISO18000-6B' AND antenna_id=1
	Lock	id: 64 bit (hex) addr: integer [8…223]	error_code OR success_notification	UPDATE tag_data SET locked=1 WHERE id=0x1234567890ABCDEF AND blocknum=12 AND protocol_id='ISO18000-6B' AND antenna_id=1

Examples

Example 1

```
DECLARE query CURSOR FOR SELECT id,
antenna_id FROM tag_id WHERE id =
0x123412341234123412341234;

FETCH query;
```

could return

```
0x123412341234123412341234|2
```

if the tag was read by antenna 2 or

```
\n
```

if the tag was not found.

Example 2

To schedule intermittent reads with off times of 1 second starting at a specific time use:

```
DECLARE sleep1 CURSOR FOR UPDATE
sleep SET time_out=1000;

DECLARE real1 CURSOR FOR SELECT id
FROM tag_id;

SET auto_time real1, sleep1 = '2004-
01-22T12:43:08-05:00';
```

Example 3

To synchronize two Readers follow the following instructions.

On Reader 1:

```
DECLARE cursor_one CURSOR FOR SELECT
id FROM tag_id SET time_out=350;

SET repeat=1000, SET auto_time
cursor_one = 0;
```

The first Reader will start reading for no less then 350 ms (it will probably run over to roughly 500 ms) starting at time zero, and it will repeat the command every 1000 ms.

On Reader 2:

```
DECLARE cursor_two CURSOR FOR SELECT
id FROM tag_id SET time_out=350;

SET repeat = 1000, SET auto_time
cursor_two = 500;
```

The second Reader will start reading for no less then 350 ms (it will probably run over to roughly 500 ms) starting at time 500ms, and it will repeat the command every 1000 ms.

The effect will be that each Reader will have a 50% duty cycle with each one only active when the other one is off.

Declarations

Regulatory Compliance

EMC.....47 CFR, Part 15(USA)
..... RS210(Canada)
Safety .....UL 60950
Can/CSA C22.2 No 60950
EN 60950

FCC COMPLIANCE: This equipment complies with Part 15 of the FCC rules for intentional radiators and Class A digital devices when installed and used in accordance with the instruction manual. Following these rules provides reasonable protection against harmful interference from equipment operated in a commercial area. This equipment should not be installed in a residential area as it can radiate radio frequency energy that could interfere with radio communications, a situation the user would have to fix at their own expense.

EQUIPMENT MODIFICATION CAUTION: Equipment changes or modifications not expressly approved by OMRON Corporation, the party responsible for FCC compliance, could void the user's authority to operate the equipment and could create a hazardous condition.

IMPORTANT USER INFORMATION: In order to comply with FCC requirements for RF exposure safety, a separation distance of at least 21 cm (8.3in) needs to be maintained between the radiating elements of the antenna and the bodies of nearby persons.

Other Declarations

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