Thinkify, LLC

The TR-200 Desktop RFID Reader

Setup Guide and Protocol Reference

DRAFT Version 0.8 DRAFT

October 2010

Legal Notices

Note Regarding RF Exposure

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 20cm between the radiator (antenna) and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

FCC Notice and Cautions

Any changes or modifications to this device not expressly approved by Thinkify, LLC could void the user's authority to operate the equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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.

About Thinkify, LLC

Thinkify, LLC is a wireless technology company specializing in RFID hardware and software products. With 30 years of combined experience in RFID and over 35 patents in the field, our founding team is one of the technically strongest in the industry.

Our focus is *embedded* RFID. -- Applications where we use RFID to enable common objects, devices and whole environments to become aware of the world around them. This capability can transform the way people and objects interact, blurring the line between the physical world and the virtual.

Thinkify is a privately held company, located in Morgan Hill, California.

We feel that partnerships should be healthy and that Engineering should be beautiful.

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Thinkify – Making things think. (tm)

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Introduction

This document explains how to set up and communicate with a Thinkify, TR200 desktop RFID reader. We call this device, the ***Insight***(tm)*.*

Most UHF RFID readers today are industrial devices focused on automating data capture without human intervention. These readers are big, expensive and run at RF power levels that require a minimum standoff from people for safe operation. While fine for industrial applications like reading pallets at dock doors, these readers are a poor fit for use cases like tag commissioning or document tracking at your desk.

The Thinkify ***Insight***(tm) is the first in a new class of RFID reader – a *Personal Reader* designed to work around people handling tagged items in an store or office environment. Like the Personal Computer changed computing, we think the Personal Reader will change the nature of RFID.

The ***Insight***(tm) is a highly capable and easy-to-use Gen2 reader designed for tag commissioning, document tracking, point of sale and other use cases where people and tags come together.

We think it's pretty. We hope you do, too.

Let's get started.

Getting Started

What's in the box?

- A TR200 Desktop Reader
- An antenna
- A USB cable'
- A CD with this manual, software driver and demonstration program
- Some sample RFID Tags

(Stone not included.)

Hooking up the hardware

Attach the antenna to your reader. – It screws on.

Plug the USB cable into the reader and then into your laptop or PC.

You should see the blue LEDs on the front of the reader cycle through a start up pattern and then the one should slowly blink to indicate that the unit has power and is waiting for commands.

So much for hooking up the hardware... You're done.

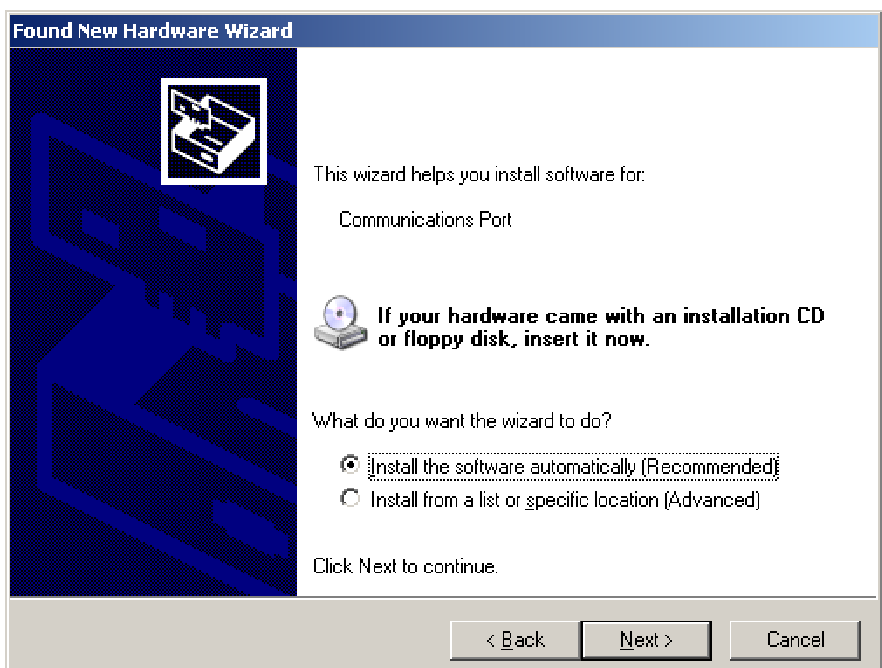
Setting up the Driver (Microsoft Windows)

After you hook up the hardware, if you've never installed the driver software for the reader on your computer you will see a message indicating that Windows doesn't know about this device.

Under windows XP, the message looks like this:

We're going to handle this ourselves so select the “No, not this time” option and click “Next”.

In the following dialog select “Install the software automatically”. Insert the CD and click “Next”.

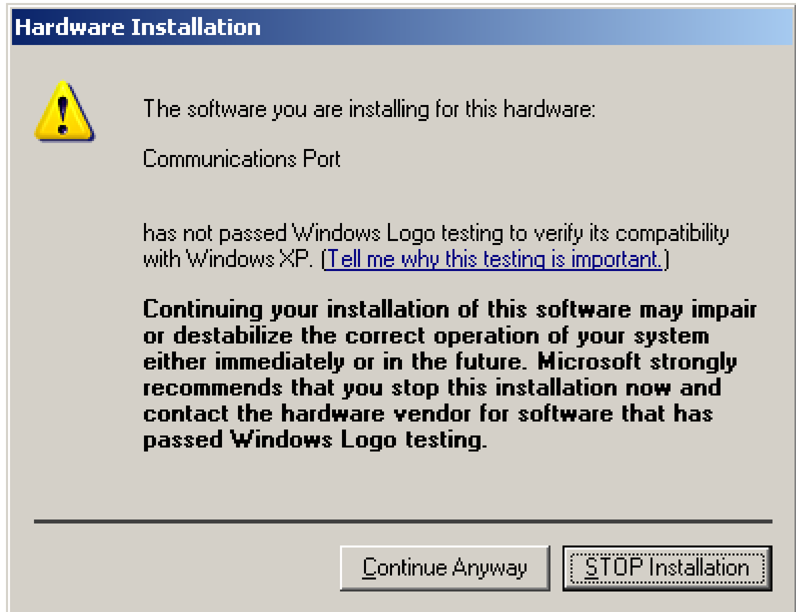


(If you chose to have the software install automatically skip ahead. Otherwise, a dialog will appear where you can select the “Include this location in the search” option and “Browse” to the \inf directory on your CD.)

After clicking “Next” you'll get a warning that the Thinkify driver has not passed the Microsoft Windows Logo testing program.

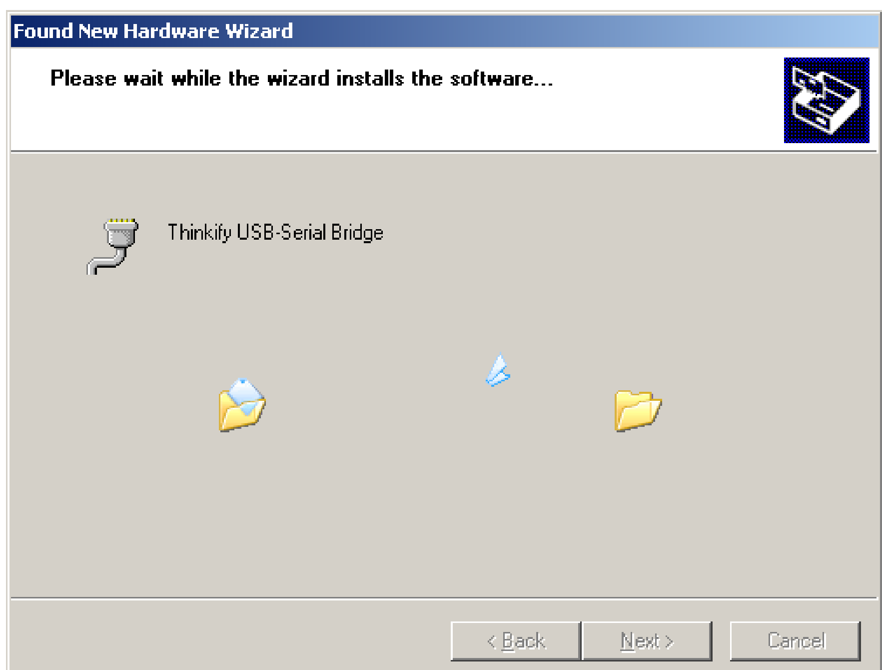
We haven't.

In fact, we never even tried.



If you still trust us, click “Continue Anyway”...

The driver will now install.



Here we map the USB you've plugged into to a “virtual” serial port.

If all goes well, you should see this screen. Click “Finish”

The driver is installed and your reader should be ready to use.

Communicating with the Reader

Application software that talks to the TR200 opens up a connection on the virtual serial port we enabled with our driver. We can test this interface with nearly any serial communication program.

Most Windows systems we've encountered come with a serial communication program called HyperTerminal installed under:

`“Start/ All Programs /Accessories / Communications”`

We will use HyperTerminal in our examples below.

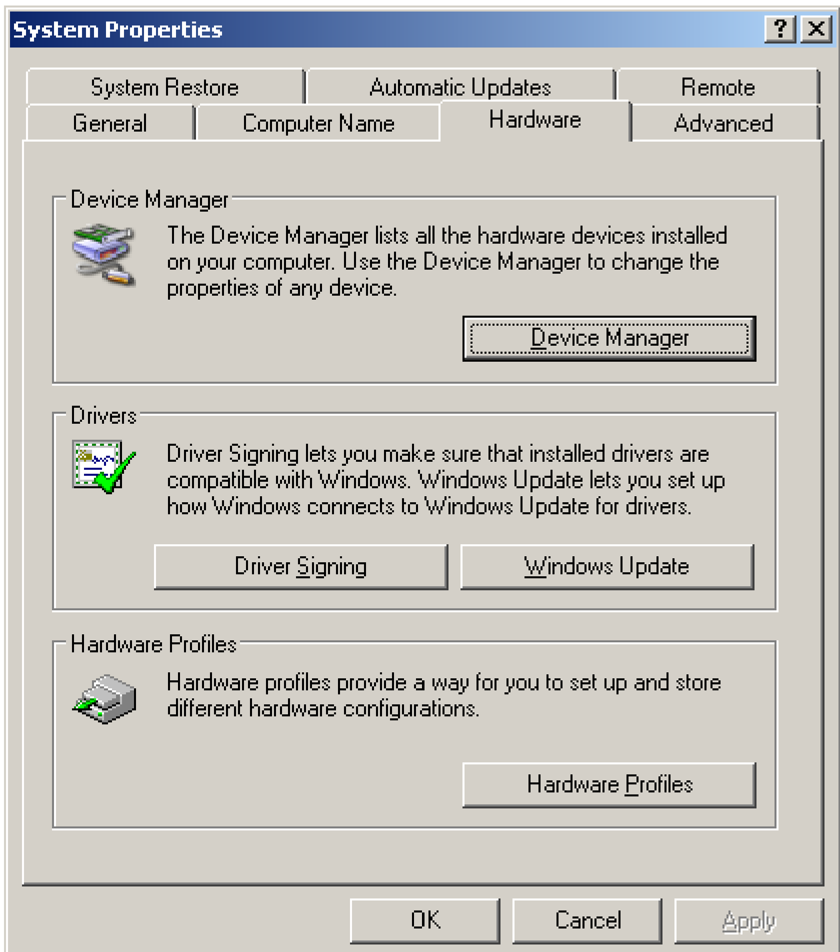
A free, less buggy and far more capable serial communication program is Tera Term. In addition to serial communication, Tera Term supports several network communication standards including telnet and ssh. We recommend Tera Term for developers who want to do more than casual explorations with HyperTerminal.

Tera Term is available for download at: http://ttssh2.sourceforge.jp/

Determining your Com Port

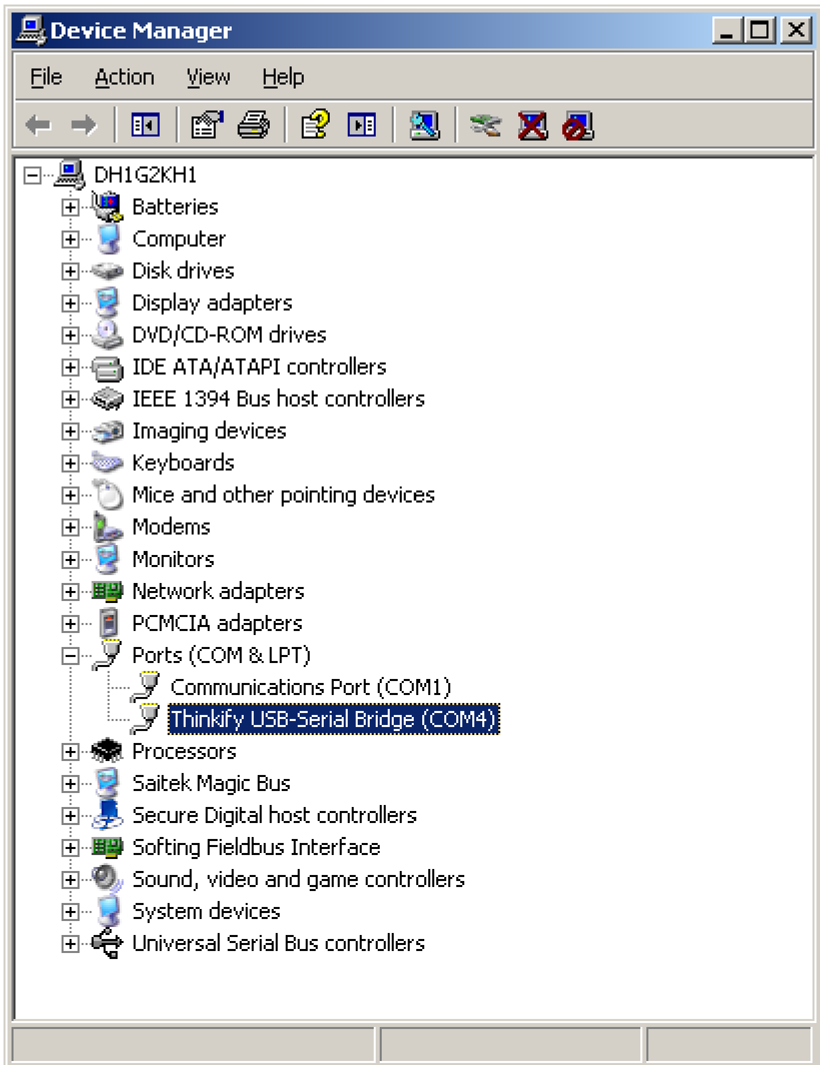
Once the driver is installed, the next time you connect the reader to a USB port, it will be recognized and given a virtual com port number. Each USB port you connect to will be given a different number by default.

You can see the com port number you obtained by going to the `Start / Control Panel / System` utility and click the Device Manager button in the hardware tab. See below:



Click "`Device Manager`" and expand the "`Ports (Com and LPT)`" option. Look for the *Thinkify USB-Serial Bridge* entry and note the com port.

On my system it came up as COM4[*]



You now know!

---

*NOTE for advanced users using Windows XP: If you wish to change the com port number, you can by right clicking on the entry for the *Thinkify USB-Serial Bridge*, selecting *Properties*, going to the *Port Settings* Tab and clicking the *Advanced* button. The dialog window has a drop down list of available com port names you may choose from.

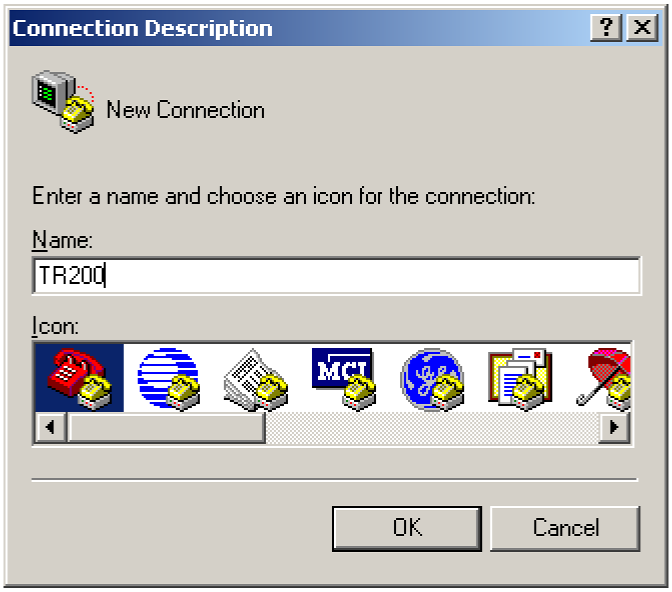
Using Hyperterminal

From the Start Menu, go to:

`"Start /All Programs / Accessories / Communications",`

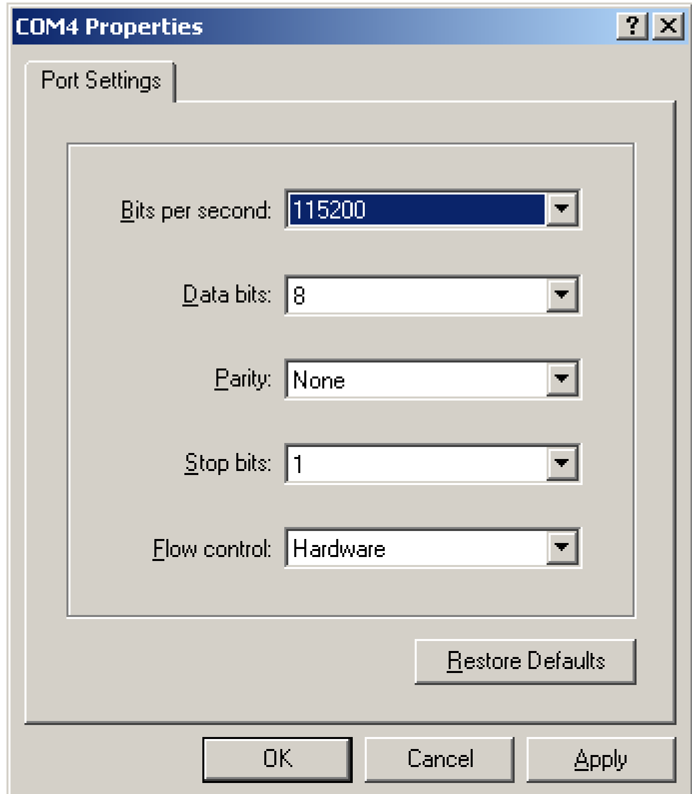
and launch HyperTerminal.

At the dialog box, create a new connection for the TR200.



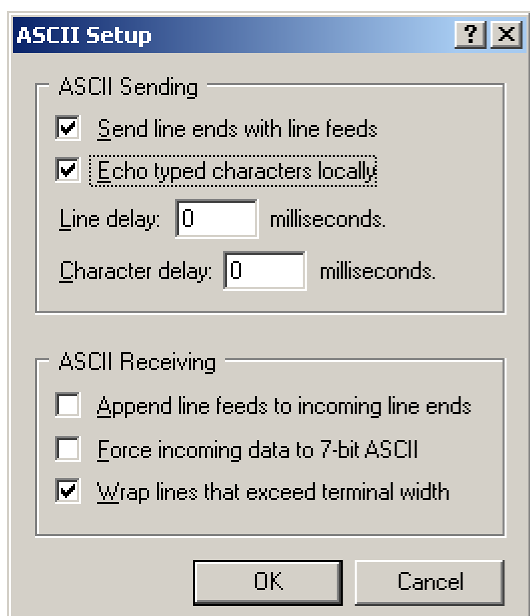
Pick the Com Port your reader is connected to.

Set your communication parameters:



From the "File/Properties" Menu, select the "Settings" Tab and click Ascii Setup.

Check "Send Line ends with line feeds" and enable local echo so you can see the commands you type.

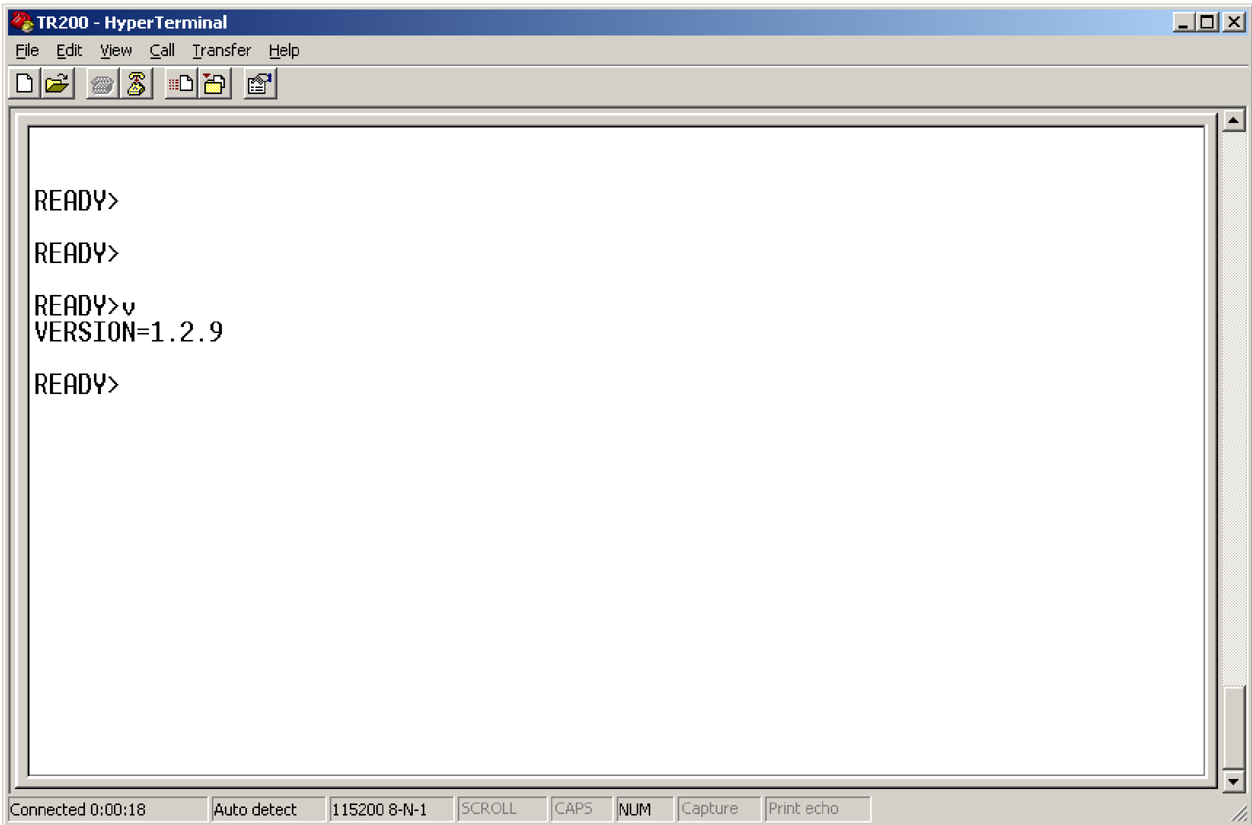


Hit OK.

Congratulations! You're setup. Let's see if we're talking...

Hit enter a few times and type `"v"[enter]` to get the reader's firmware version.

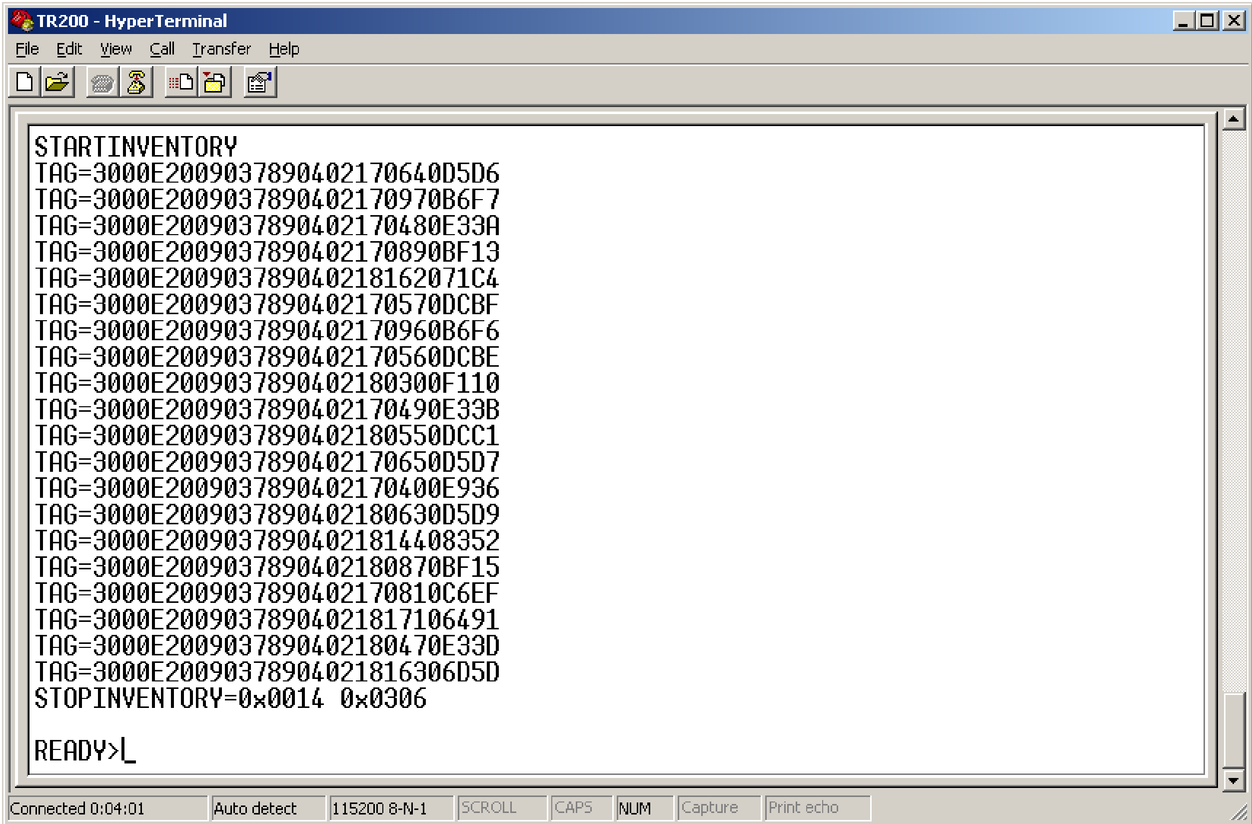
You should see something like:



Your reader is alive and talking!

In the following sections, we describe the protocol structure and list the commands that the reader can respond to using this interface. You can try out all the commands using HyperTerminal to get a feeling for how they work. After that, you can use our software APIs or roll your own to use the same commands from your own programs.

As an example, let's read some tags. Hold up your sample tags near the reader and type `"t"[enter]` You should see something like this:


TR200 - HyperTerminal
File Edit View Call Transfer Help
STARTINVENTORY
TAG=3000E200903789040217064 0D5D6
TAG=3000E20090378904021709700B6F7
TAG=3000E20090378904021704 80E33A
TAG=3000E20090378904021708900BF13
TAG=3000E20090378904021816 2071C4
TAG=3000E20090378904021705700DCBF
TAG=3000E20090378904021709600B6F6
TAG=3000E20090378904021705600DCBE
TAG=3000E20090378904021803000F110
TAG=3000E20090378904021704900E33B
TAG=3000E20090378904021805500DCC1
TAG=3000E20090378904021706500D5D7
TAG=3000E20090378904021704000E936
TAG=3000E20090378904021806300D5D9
TAG=3000E2009037890402181440 8352
TAG=3000E20090378904021808700BF15
TAG=3000E20090378904021708100C6EF
TAG=3000E20090378904021817106491
TAG=3000E20090378904021804700E33D
TAG=3000E2009037890402181630 6D5D
STOPINVENTORY=0x0014 0x0306
READY>
Connected 0:04:01
Auto detect
115200 8-N-1
SCROLL
CAPS
NUM
Capture
Print echo

Victory!

A Quick RFID Introduction

Class 1 Generation 2 (Gen2)

The RFID tags included in your reader kit conform to the UHF Class 1, Generation 2 standard maintained by EPC Global. (REF). EPC Global is a division of UPC – The same standards organization that controls the barcode numbering system used on retail packages. This standard (with minor changes) is also maintained by ISO under ISO-18000-6-C. (REF)

Most Gen2 tags (as they are usually called) are *Passive* RFID devices. That is, they do not require a battery and derive their power for operation from the RF field sent out by the reader. This allows them to be small, inexpensive and operate virtually indefinitely.

Most Gen2 tags are also programmable devices. Users can put their own information into the tags. The amount of data that can be stored depends on the type of tag but hundreds of bits are typical. Data in the tag is organized into “Banks” of memory that serve different functions under the protocol:

- Bank 0: Reserved Memory Kill and Access Password space.
- Bank 1: EPC Memory The unique tag identifier. Typically 128 bits. User programmable. The Gen2 protocol is designed to extract this information quickly.
- Bank 2: TID Memory A factory programmed area that includes a serial number and fields that describe the tag's capabilities.
- Bank 3: User Memory A programmable extended memory area for holding additional information that is not the EPC. Not all tags support User Memory.

Gen2 tag memory can be “Locked” such that it cannot be changed without a passcode. These locks can be reversible or permanent.

Finally, Gen2 tags can be rendered non-functional with a “Kill” command. Tags that are killed cannot be recovered.

Concepts (Performing an Inventory)

Being an RFID reader trying to read multiple tags using the Gen2 protocol is sort of like being a new teacher trying to take attendance in a kindergarten class... Sadly, the administration didn't give you an attendance list on the first day of class so you have to work it out for yourself.

Kindergarten Teacher	**RFID Reader**
You have to get a list of everyone's name	You have to get a list of all of the EPC codes from the tags
Kids know their own names	Tags have unique IDs in EPC memory they can report
You can only hear one child at a time	The reader can only process a signal from one tag at a time
Kids want to all talk at once	Multiple tags can respond at the same time

What both the reader and the teacher need is an *anti-collision protocol* – a way to keep their respective tags/kids from talking at the same time.

Most teachers adopt an adult-talks-first protocol with a persistent state flag for whether a child has been inventoried. This flag is maintained in the child. Sometimes there's a bi-directional exchange with an ACK/NAK option. Hey! that's a lot like Gen2.

“Huh?” You say.

Teacher: *“Ok everyone! Quiet down. It's time to take attendance.”* (Reader-talks-first)

Teacher: *“Ok everyone! Hands up!”* (Under Gen2 this is a *Select* command that establishes who's going to participate in the inventory. – In this case, everyone. By putting their hands up, the child has set a flag that indicates he/she hasn't been inventoried, yet.)

Teacher: *“When I point to you, tell me your first name.”* (Granted this is a little contrived, but it's a little like the *Query* command in Gen2 that kicks off an inventory sequence.)

The teacher randomly picks the first child, points to her and says, *“You!”*

Child: *“Inga!”* (In Gen2, a tag responds to a *Query* with a random number that is used in the next command by the reader)

Teacher: *“Inga who?”* (This is like a Gen2 *ACK* (acknowledgment). It tells the tag/child that the reader/teacher heard their response and is now asking them for their data.)

Child: *“Svenson!”*

Teacher:*”You!”* (Pointing to the next child. At this point, Inga assumes that the teacher got her name, since she's moved on to the next child. She puts her hand down and sets her state to “Inventoried”)

Child: *“Mikey!”*

Teacher: *“Mikey who?”*

Child: *“Jones!”*

Teacher: *“Pardon me?”* (If the reader doesn't understand the reply it can issue a *NAK* and try again.)

Teacher: *“Mikey who?”*

Child: *“Jones!”*

Teacher: *“You!”* (On to the next child. Mikey puts his hand down, too.)

And off they go...

When the teacher reaches the end of the round, (See's no more raised hands in this case) she's done.

This is clearly contrived and is an oversimplification of both the Teacher's real-life protocol and Gen2, but it does captures some of the important features:

1. Inventories of the field need an anti-collision protocol to prevent multiple tags from talking at the same time.
2. An inventory can begin with one or more *Select* commands that establish who will participate in the inventory. (Teacher: “Ok, only the boys, put your hands up!”)
3. The state of whether or not a tag has been inventoried is maintained in the tag.
4. In the process of singulating a tag, the reader gets a handle (the child's first name in the example above) that it can use for additional operations with that tag (more on this below).

The analogy breaks down when you realize that unlike the teacher, the reader cannot see the inventoried state of the tags (hands in the air). If the teacher tried to take attendance of the class from behind a curtain, it would be a lot more difficult. Rather than pointing at a child and saying, “You!” to keep them from talking at once, a different protocol would be needed.

In Gen2, this is accomplished with the *Query* command. When the reader issues a *Query* command, it includes in the message a parameter called Q that the tags use to determine if they will respond immediately, or after some number of subsequent

QueryRep commands. The number of *Query* or *QueryRep* commands the tag will wait to hear is determined randomly and can vary from 1 to 2^Q.

By adjusting the Q parameter used in its *Query* commands, the reader can prevent multiple tags from responding simultaneously most of the time. If there is a collision, the reader can adjust Q or just try again and let the tags roll a different random number. From your perspective as a user of the reader, these details don't usually matter (we adjust Q for you automatically) but they can be useful to know sometimes if you are trying to optimize performance.

Concepts (Reading / Writing other data)

The Gen2 protocol is strongly oriented around the use case of rapidly reading the data in Bank 1 of Memory (the EPC). In supply chain applications there can be hundreds of tags moving past a read point and the reader needs to read them all as they go by.

Reading other data in other banks of memory or programming builds off of the protocol we use for isolating tags and it extends it to allow a “conversation” to take place with a tag we've isolated.

To read user memory for example, the reader first isolates a tag with an inventory and then uses the handle from the tag as part of a sequence of commands to get the other data. Writing is similar.

In the Thinkify reader, we allow you to specify a number of “Descriptors” that tell the reader what additional actions (if any) to take when it reads a tag. Descriptors can be used to Read additional memory areas, Write to memory, Lock and Unlock tag Memory and Kill tags.

This is a very powerful approach. By using Select commands (a.k.a. Masking) as part of the inventory we can quickly specify that we are interested in performing an operation on just one, some or all of the tags present in front of the reader.

Thinkify Reader Protocol Overview

Here we give an overview of the Thinkify Reader Protocol message structure and provide a high-level summary of the major command groups available to the user.

The Thinkify Reader Protocol (TRP) is a human-readable ASCII protocol that allows users and applications to set parameters for RF control, tag list acquisition, tag programming and digital I/O behavior. The TRP may also be used to acquire data from the reader and be notified of tag read events, I/O events and reader status.

The TRP is used across all Thinkify reader products and supported hardware interfaces including; RS232, USB and Ethernet.

Command Structure

The Thinkify Reader Protocol uses a Command-Response model. --Communication is initiated by the Host and the Reader responds with an acknowledgment or data.

Users may interact with the reader from a terminal program or their own software using the Thinkify APIs. All that is required is that they send strings to the device over an active connection and terminate messages correctly. Replies will be sent back, often on multiple lines, terminated by a “READY>” prompt.

Host Commands

Host commands to the Reader are ASCII strings terminated with a Carriage Return.

Valid command messages are composed of numeric characters in the range of 0-9 (0x30 to 0x39) ASCII characters in the range of a..Z (0x to 0x) and the carriage return character (0x0D).

Line feed characters are ignored by the reader and may be sent without effect. --The Reader does not echo commands back to the Host.

The general format of a Host to Reader message is:

```
<COMMAND>[<SUBCOMMAND>[<PARAM1>][<...>][<PARAMn>]]<CR>
```

(Here [] denotes an element that may be optional.)

- `<COMMAND>` is typically a single character.
- `<SUBCOMMAND>` is typically a single character
- `<PARAMs>` vary in length and depend on the command being sent. (See details below). There are no spaces between parameters if multiple parameters are sent as part of a message.

- `<CR>` is the Carriage Return CR character (0x0D). Upon receipt of a carriage return, the Reader will attempt to parse the command message and execute the command if properly formatted.

Reader Replies

Reader replies to Host commands are also ASCII strings. Replies may be either a single line or a multi-line reply, depending on the Command. Each line of a reply is terminated with a Carriage Return + Line Feed character pair, CRLF (0x0D,0x0A)

When the reader has finished sending all data back to the host in response to the command, it will end the sequence with a “READY>” prompt, indicating is prepared to process another message. Generally, after sending a Command, the Host should not send a new command until it sees the "READY>" message.

The general format of a Reader to Host message is:

```
[STARTMSG<CRLF>]
<Line1><CRLF>
<Line2><CRLF>
…
<Linen><CRLF>
[STOPMSG<CRLF>]
<CRLF>
<READYPROMPT>
```

(Here [] denotes an element that may be optional.)

- `[STARTMSG]` – Indicates the beginning of command processing. – Not sent on every command. Sent on commands where inventories are performed.
- `<Lines>` – Data sent back in response to the command
- `[STOPMSG]` – Indicates command processing is finished. – Not sent on every command. Send on commands where inventories are performed.
- `<READYPROMPT>` – “READY>” prompt. Indicates that the reader is ready to accept another command.

Special Case: Inventory Replies

When the Reader performs a T or Tn command that is setup for infinite repeat, it will stream line data until it sees a character from the host. It will then terminate the message with the STOPMSG and READYPROMPT. (See T commands below for examples and discussion.)

Examples

Example – To set the General Purpose Output (GPO) Pin 1 to a High Level

```
<COMMAND=”G”><SUBCOMMAND=”1”><PARAM1=”1”><TERM=0x0D>
```

The Host would have to send the string:

```
G11<CR>
```

The Reader would respond with:

```
GPOUTPUT1=1<CRLF>
READY>
```

Example: – Read Tags using the “T” command.

```
<COMMAND=”T”>
```

Host:

```
T<CR>
```

Reader:

```
STARTINVENTORY<CRLF>
TAG=3000100000000000000000003560<CRLF>
TAG=3000100000000000000000003568<CRLF>
TAG=300010011002100310041007BBBB<CRLF>
TAG=3000100000000000000000003583<CRLF>
TAG=3000100000000000000000003556<CRLF>
TAG=3000100000000000000000003569<CRLF>
TAG=3000100000000000000000003557<CRLF>
TAG=3000BBAA99887766554433221100<CRLF>
TAG=3000100000000000000000003582<CRLF>
STOPINVENTORY=0x0009 0x00EA<CRLF>
<CRLF>
READY>
```

Example – Query the Inventory Parameter Settings

```
<COMMAND=”I”>
```

Host:

```
I<CR>
```

Reader:

```
SELTYPE=1<CRLF>
SESSION=1<CRLF>
TARGET=0<CRLF>
Q=0x3<CRLF>
OUTERLOOP=0x01<CRLF>
INNERLOOP=0x03<CRLF>
SELECTLOOP=0x1<CRLF>
<CRLF>
READY><CRLF>
```

Example: --Tn command

Tn (T1, T2, ...T6) commands repeatedly perform inventories until interrupted by the Host. During this time the Reader will stream tag data until a character is received from the Host. The reader will then stop the Inventory sequence and terminate the reply.

Host:

```
T6<CR>
```

Reader:

```
STARTINVENTORY<CRLF>
TAG=300010000000000000000000003582 911750 07 8 9 Q E468<CRLF>
TAG=300010000000000000000000003557 911750 04 8 9 I E471<CRLF>
TAG=300010000000000000000000003583 911750 06 8 9 Q E47C<CRLF>
TAG=300010000000000000000000003557 911750 02 8 9 I E486<CRLF>
TAG=300010000000000000000000003557 911750 06 8 9 I E493<CRLF>
TAG=300010000000000000000000003568 911750 02 8 9 Q E49D<CRLF>
TAG=300010000000000000000000003557 911750 07 9 A I E4A9<CRLF>
TAG=3000BBAA99887766554433221100 911750 02 9 A Q E4B4<CRLF>
TAG=300010000000000000000000003556 911750 07 7 0 I E4C3<CRLF>
TAG=300010000000000000000000003557 911750 00 7 0 Q E4D3<CRLF>
TAG=300010000000000000000000003557 911750 05 7 0 Q E4DD<CRLF>
TAG=300010000000000000000000003569 911750 06 7 0 I E4ED<CRLF>
TAG=300010000000000000000000003583 911750 04 7 0 I E4F5<CRLF>
TAG=300010000000000000000000003560 911750 02 7 0 Q E4FD<CRLF>
TAG=300010000000000000000000003557 911750 00 7 0 Q E506<CRLF>
```

Character (space) received from the Host!

```
TAG=300010000000000000000000003569 911750 07 7 1 I E511<CRLF>
TAG=300010000000000000000000003557 911750 01 7 1 Q E51C<CRLF>
STOPINVENTORY=0x0011 0x00C6<CRLF>
<CRLF>
READY><CRLF>
```

Command Groups

Commands are grouped into five major areas: functions for working with RFID tags, functions for controlling the reader's radio subsystem, functions for interacting with the reader's GPIO port, system commands for firmware updates, etc., and advanced engineering functions used mostly for regulatory testing and by users wishing to develop custom OEM solutions.

Tag Commands

GPIO and Triggering

Radio Control Commands

System Commands

Engineering Test Functions

Command Reference

Summary

A quick overview of the main command groups follow. Detailed explanations are in the following sections.

Main Command	Description	Command Group
A	RX Amplifier Control	Engineering / Test
B	Enter Bootloader	System
C	Low-Level Chip Registers	Engineering / Test
D	Diagnostic Functions	Engineering / Test
F	RX Filter Control	Engineering / Test
G	GPIO Control	GPIO Control and Triggering
I	Inventory Control	Tag Commands
K	Kill / Access Data Descriptors	Tag Commands
L	Low-Level Tests	Engineering / Test
M	Tag Masking	Tag Commands
P	Protocol Air Interface	Radio Control
R	RF Control	Radio Control
S	Status Functions	System
T	Perform Tag Inventory	Tag Commands
V	Get Firmware Version (Read Only)	System
X	eXtra Read / Write Data Descriptors	Tag Commands

"A" RX Amplifier Control

Description

The “A” command and sub-commands are used to set and get the parameters that control the characteristics of the amplifier in the base band receiver.

Command Group

Engineering / Test

Command

```
<A>[<SUBCMD>[<PARAMS>]]
```

Sub-Commands

Sub Command	Description	Legal Values for SET
AA	8 dB mixer attenuation control. – Off or On.	0..1
AG	Gain adjustment: **Value** **Gain** 0 0dB 1 -9dB 2 -6dB 3 -3dB 4 +3dB 5 +6dB 6 +9dB	0..6
AH	Hysteresis: 7 steps of 3dB ea.	0..7
AM	10 dB mixer amplification control. Off or On.	0..1

"A" Command Examples

Get All Settings

```
READY>a
INPUTATTEN=1
GAIN=-0
HYSTERESIS=0
MIXERBOOST=0

READY>
```

Set the Gain

```
READY>ag2
GAIN=-6

READY>\
```

"BOOTLOADER" – Enter Bootloader

Description

Places the reader in a special mode where it is waiting to receive a firmware upgrade. In this state, the reader will not respond to normal commands and requires a power cycle to return to normal operation. See Appendix A for how to upload firmware using the Thinkify Upgrade Utility.

Note

Entering bootloader mode un-enumerates the USB port in Windows. Reset into normal code re-enumerates port.

This can confuse terminal programs like Tera Term / Hyperterm. After executing the bootloader command disconnect terminal program. After resetting and re-enum then reconnect terminal program.

The host Bootloader program provided by Thinkify for firmware upgrades runs the USB interface with a HID windows class driver. (Normal operation is with a windows CDC class driver.)

Command Group

System

Command

```
<BOOTLOADER><CR>
```

"Bootloader" Example

```
READY>bootloader
ENTERINGBOOT
```

The reader is now waiting for a firmware upgrade. At this point you may use the Thinkify Upgrade Utility to load new firmware. See Appendix A.

"C" Low-Level Chip Control Registers

Description

The “C” command and sub-commands are used to set and get the low-level control registers in the AM3392 chip. (An engineering command.)

Command Group

Engineering / Test

Command

```
<C>[<SUBCMD>[<PARAMS>]]  - see table.

<C><ADDR><VAL>  - sets a register. ADDR may be one or two nibbles. VAL
may be 2 or 6 nibbles.
```

Sub-Commands

<table>
<tr><th>Sub Command</th><th>Description</th><th>Legal Values for SET</th></tr>
<tr><td>C</td><td>Report all registers
<table>
<tr><th>Register</th><th>Description</th></tr>
<tr><td>0x00</td><td>Status control (byte)</td></tr>
<tr><td>0x01</td><td>Protocol control (byte)</td></tr>
<tr><td>0x02</td><td>TX option (byte)</td></tr>
<tr><td>0x03</td><td>RX option (byte)</td></tr>
<tr><td>0x04</td><td>TRcal Low reg (byte)</td></tr>
<tr><td>0x05</td><td>TRCal Hi reg (byte)</td></tr>
<tr><td>0x06</td><td>TX Delay (byte)</td></tr>
<tr><td>0x07</td><td>RX No Resp Wait (byte)</td></tr>
<tr><td>0x08</td><td>RX Wait (T1) (byte)</td></tr>
</table></td><td>-</td></tr>
</table>

Sub Command	Description		Legal Values for SET
	Register	**Description**	
	0x09	RX Filt Reg (byte)	
	0x0A	RX Spec2 (byte)	
	0x0B	Regulator and RF control (byte)	
	0x0C	-	
	0x0D	IRQ Mask (byte)	
	0x0E		
	0x0F		
	0x10		
	0x11	Test Select Reg (byte)	
	0x12	Test Setting reg (word)	
	0x13		
	0x14	CLSYS ANAOUT (word)	
	0x15	MOD control (word)	
	0x16	PLL main control (word)	
	0x17	PLL aux control (word)	
	0x18	DAC reg (byte)	
	0x19		
	0x1A	RXLen1 (byte)	
	0x1B	RXLen2 (byte)	
	0x1C		

<table>
<tr><th>Sub Command</th><th>Description</th><th>Legal Values for SET</th></tr>
<tr><td></td><td><table><tr><th>Register</th><th>Description</th></tr><tr><td>0x1D</td><td>TXLEN1 (byte)</td></tr><tr><td>0x1E</td><td>TXLEN2 (byte)</td></tr></table></td><td></td></tr>
<tr><td>CS</td><td>Report all shadow registers</td><td>-</td></tr>
<tr><td>CR</td><td>Resets all registers to program default.</td><td>-</td></tr>
</table>

"C" Command Examples

Get all values:

```
READY>c
REG00=0x20
REG01=0x4D
REG02=0xE1
REG03=0x92
REG04=0x41
REG05=0xC3
REG06=0x00
REG07=0x05
REG08=0x03
REG09=0x37
REG0A=0x81
REG0B=0x58
REG0C=0x00
REG0D=0x3F
REG0E=0x03
REG0F=0x00
REG10=0x78
REG11=0x00
REG12=0x00004000
REG13=0x51
REG14=0x00008413
REG15=0x00403F06
REG16=0x0064A907
REG17=0x00011846
REG18=0x00
REG19=0x00
REG1A=0x00
REG1B=0x00
REG1C=0x00
REG1D=0x00
REG1E=0x00

READY>
```

“D”- Diagnostic Functions

Description

The D command and sub-commands are used to control Scope triggers and pulses coming directly from the AM chip. These may be used in troubleshooting and regulatory testing. (An Engineering function.)

Command Group

Engineering / Test

Command

```
<D>[<SUBCMD>[<PARAMS>]]
```

Sub-Commands

Sub Command	Description	Legal Values for SET

DT	Set Inventory Parameters to Default Values
	`0 = No Trigger`
	`1 = Trigger when a SELECT command is sent`
	`2 = Trigger when a QUERY command is sent`
	`3 = Trigger when a ACK command is sent`
	`4 = Trigger when a REQRN command is sent`
	`5 = Trigger when a READ command is sent`
		0..5

DD	Sends a direct command out the IC. (no Get) Values a mystery --known only to the Dark Code Lord.	0..FF?

“D” Command Examples

GET and SET

```
READY>dt
SCOPETRIGGER=0x00

READY>dt4
SCOPETRIGGER=0x04

READY>
```

"F" RX Filter Control

Description

The F command and sub-commands are used to control the RX baseband filter. These commands may be used in troubleshooting and regulatory testing. (An Engineering test function.)

Command Group

Engineering / Test

Command

```
<F>[<SUBCMD>[<PARAMS>]]
```

Sub-Commands

Sub Command	Description	Legal Values for SET
F	Report current filter settings.	-
FH	Hi Pass value	0..7
FL	Low Pass Value	0..7

FB	By Pass Filter
	`Bit 0 = 40 KHz`
	`Bit 1 = 160 KHz`
		0..3

FS	AC Speedup	0..1

"F" Command Examples

GET and SET

```
READY>f
FILTER PARAMS
LOWPASS=6
HIGHPASS=7
BYPASS160=0
BYPASS40=0
ACSPEEDUP=0

READY>fl5
LOWPASS=5
```

"G" GPIO Settings

Description

The G command and sub-commands are used to control the GPIO port. These may be used to set/retrieve GPIO pin settings or to set the reader up for triggered reading.

Using the GT command, the reader may be configured to read tags in any of the supported inventory modes for either a fixed time after an edge transition or while a pin is held in a particular state.

Command Group

GPIO Control and Triggering

Command

```
<G>[<SUBCMD>[<PARAMS>]]
```

Sub-Commands

Sub Command	Description	Legal Values for SET
G	Reports current state of input and output lines	-
G0	Write Output Port 0 (no Get)	0..1
G1	Write Output Port 1 (no Get)	0..1

GT	Triggering setup for Autonomous Reading
	`GT<port (nibble)> <active (nibble)> [<type (nibble)> <action (nibble)> <time (byte)> (if active)]`
	`<TYPE (0= posedge, 1 = negedge, 2= poslevel, 3 neglevel)>`
	`<ACTION (0 = T3, 1= T4, 2 = T5, 3 = T6, 4 = T)>`
	`<TIME (if edge only - range 0x01 to 0xFF in .1sec units for .1 to 25.5 seconds)>`
		See Description

"G" Command Examples

GET and SET

```
//Get the current settings
READY>g
GPINPUT0=1
GPINPUT1=0
GPOUTPUT0=0
GPOUTPUT1=0

//Get Trigger Settings
READY>gt
TRIGGERTYPE=DISABLED

//Configure for edge trigger on port 1 for 10 seconds (0x0A seconds)
READY>gt11040a
TRIGGERTYPE=POSEDGE PORT1
TRIGGERACTION=T 0A

READY>
```

"I"- Inventory Control

Description

The I command and sub-commands are used to set and get the parameters that control the flow of the Gen2 anti-collision algorithm. Modifications to the default parameters may be helpful in cases where there are a large number of tags in the field or when it is desirable to increase the number of redundant reads for a given tag.

Command Group

Tag Commands

Command

```
<I>[<SUBCMD>[<PARAMS>]]
```

Sub-Commands

Sub Command	Description	Legal Values for SET
ID	Set Inventory Parameters to Default Values	-
II	Inner Loop Count: Each INNERLOOP runs a tag acquisition STATEMACHINE	0..FF
IL	Gen2 SEL Flag: Value used in QUERY for the SEL field. See G2 spec. (Usually set to 0)	0..3
IO	Outer Loop Count: Number of FULL INVENTORY ITERATIONS (one iteration is a SELECT group and a INNER LOOP group)	0..FF
IQ	Gen2 Q Parameter: The Q used in the QUERY that starts the round	0..8
IS	Gen2 Session: The session (0 to 3) that will be used for the entire inventory run.	0..3
IT	Inventory Target: Defines whether the QUERY that initiate round is looking for tags in the A or B state	0..1

Sub Command	**Description**	**Legal Values for SET**
IW	Select Count: Number of times SELECT function is executed - each execution sends every MASK that is enabled	0..F
IX	Append XPC Data Flag	0..1

"I" Command Examples

GET

```
//Get all parameters
READY>i
INVENTORY PARAMS
SELTYPE=1
SESSION=1
TARGET=0
Q=0x3
OUTERLOOP=0x01
INNERLOOP=0x03
SELECTLOOP=0x1

//Get just the Q value
READY>iq
Q=0x3

READY>
```

SET

```
//Set some values
READY>iq3
Q=0x3

READY>ii4
INNERLOOP=0x04

//Set it up to read until interrupted. OuterLoop = 0xFF
READY>ioff
OUTERLOOP=0xFF

READY>
```

"K" Kill – Lock – Access Descriptors

Description

The K family of commands are used to control lock kill and access command behavior. The K commands allow the user to get/set passwords used in kill, lock and access operation and specify lock type for the lock commands.

These commands are described in detail in the EPC Global C1G2 specification: uhf c1g2_standard- version 1.2.0.pdf

Command Group

Tag Commands

Command

`<K>[<SUBCMD>[<PARAMS>]]`

Sub-Commands

Sub Command	Description	Legal Values for SET

KA	Get / Set ACCESS Password
	`KA for get`
	`KA<ACCESSPASSWORD> for set.`
		32 Bits from 8 Nibbles

KAR	Clears ACCESS Password	-

KL	Get / Set Lock Descriptor
	Options:
	`KL – Report Lock Descriptor`
	`KL<active 1:0> - (De)Activate Lock descriptor`
	`KL<active 1:0><LOCKBITS (20 bits in 5 ASCII HEX nibbles)> De)Activate Lock descriptor and Set LOCK value`
		See Description

KK	Controls KILL descriptor
	`KK  report KILL descriptor`
	`KK<active 1:0> activate or de-activate the KILL descriptor`
		See Description

	KK<active 1:0><KILLPASSWORD (16 bit 4 ASCII HEX nibbles)> = activate or de-activate the KILL descriptor and setup KILL password val	

"K" Command Examples

GET

```
READY>ka
ACCESSPASSWORD=00000000

READY>kk
ACTIVE=0
KILLPASSWORD=00000000

READY>kl
ACTIVE=0
LOCKBITS=00000

//Set the LOCK active
READY>kl1
ACTIVE=1
LOCKBITS=00000
```

"L" Low-Level Tests

Description

The LF command and sub-commands are used to monitor read performance for a single tag across frequency. (An engineering test function.)

Command Group

Engineering / Test

Command

```
<L>[<SUBCMD>[<PARAMS>]]
```

Sub-Commands

Sub Command	Description	Legal Values for SET
LFQ	Reports number of responses to a Query as a function of frequency. (100 Max)	-
LFD	Reports values of the reflected power mixers v. frequency.	-
LFA	Reports Queries, ACKS and reflected power.	-

"L" Command Examples

DO (no get or set)

```
//Perform a Scan
//Frequency Queries Acks Irefl Qrefl
READY>lfa
902750 100 100 172 157
903250 100 100 172 155
903750 100 100 172 153
…..
925750 99 99 138 131
926250 90 81 138 132
926750 81 59 138 132
927250 99 89 138 133

READY>
```

“M" MASK / SELECT control

Description

As mentioned in the introductory sections, an inventory may begin with the issuance of one or more Gen2 *Select* commands to determine which tags participate in the inventory round.

When the Select loop runs (see the IW command) each pass through the loop can issue up to four (4) independent Select commands. The parameters associated with these Select commands are stored in the reader's Masks list.

When the Select is sent, the ACTIVE flag of each of the four (4) masks is examined in order from 0 to 3. If ACTIVE == 1 the MASK is used to structure the Select command.

From a RESET, MASK0 is active (ACTIVE FLAG 1) with a ACTION of 000 (ALL TAGS to A state – see G2 spec TABLE6.19 for the 8 possible ACTIONS) and a LEN of 0×00. This means “All tags selected”.

From a RESET, MASK1, MASK2, MASK3 are set to INACTIVE (ACTIVE FLAG == 0)

Command Group

Tag Commands

Command

`<M><SUBCMD><MASKNUM><PARAMS>`

Sub-Commands

Sub Command	Description
MA	Set Mask Parameters to Default Values. – Will put all masks to their defaults from a RESET state.
M	Command `<M><MASKNUM (0 to 3)>` will GET the values of the requested MASK
M	Command

Sub Command	Description

	`<M><MASKNUM (0 to 3)><PARAMS>`
	
	will PUT a MASK into MASKNUM
	`<PARAMS>`
	
	`<ACTIVE (0 or 1)>`
	0 means inactive, 1 means active
	
	`<TTYPE (0 or 1)>`
	0 means use the current Session (See: IS command)
	1 means use SL 100 flag.
	
	`<ACTION (0 to 7)>`
	TODO: Expand this section. – Until we do, we recommend you see the EPC Global G2 Spec TABLE 6.19 for the 8 possible ACTIONS.
	http://www.epcglobalinc.org/standards/uhfc1g2/uhfc1g2_1_2_0-standard-20080511.pdf
	`<MEMBANK (0 to 3)>`
	see G2 spec
	
	`<LEN byte>`
	Number of BITS in mask
	
	`<EBVBANK byte(s) (min 1 byte, max 4)>`
	`This is a BIT pointer see annexA G2 spec EBV pointers`
	
	`<MASK byte(s) (min 0, max 32 bytes)>`
	Must have enough bytes to meet LEN. All bits are LEFT justified i.e MSB of BYTE0 is first bit of mask MSB of BYTE1 is 8th of mask etc.

“M” Command Example 1

This can be tricky so let's work it out with an example:

```
Tag=3000BBAA99887766554433221100
```

With this ID we have an epc with data in the following hex bit positions:

EPC Data	3000 (pc)	BBAA	9988	7766	5544	3322	1100
Bit Position (Hex)	0x10	0x20	0x30	0x40	0x50	0x60	0x70

Say we want to mask on the first part of the EPC code of this tag. "BBAA" (3000 is the PC word) Recall the Command Structure:

```
M +
NUM +
ACTIVE +
TTYPE +
ACTION +
MEMBANK +
LEN(1 byte 2 nibbles)+
EBV(1 byte 2 nibbles MIN) +
DATA
```

To Set Mask 0 to look for “BAAA” in the right position we say:

```
M + '0'(mask) + '1'(enable) + '0'(ttype) + '0'(action)+ '1' (epc) + '10'
(16 bits) + '20'(pointer) + 'BBAA' (data)
```

Our command should be:

```
M010011020BBAA
```

We try this out below...

GET

```
//Report mask 0
READY>m0
MASK=0
ACTIVE=1
```

```
TARGET=1
ACTION=0
BANK=1
PNTR=00
LEN=00
BITS=


READY>
```

SET

```
//Look for some tags...
READY>t
STARTINVENTORY
TAG=3000100000000000000000003557
TAG=3000E2003412DC03011756040528
TAG=3000100000000000000000003582
TAG=3000BBAA99887766554433221100
TAG=3000100000000000000000003561
TAG=3000100000000000000000003560
TAG=3000100000000000000000003569
TAG=3000100000000000000000003583
TAG=3000100000000000000000003556
TAG=3000100000000000000000003568
TAG=3000100000000000000000003556
TAG=3000100000000000000000003569
TAG=3000100000000000000000003568
TAG=3000100000000000000000003561
TAG=3000E2003412DC03011756040528
TAG=3000100000000000000000003557
TAG=3000100000000000000000003582
TAG=3000BBAA99887766554433221100
TAG=3000100000000000000000003560
TAG=3000100000000000000000003583
STOPINVENTORY=0x0014 0x01C8


//Let's set the reader to only report our favorite tag!
READY>m010011020bbaa
MASK=0
ACTIVE=1
TARGET=1
ACTION=0
BANK=1
PNTR=20
LEN=10
BITS=BBAA
```

```
READY>t
STARTINVENTORY
TAG=3000BBAA99887766554433221100
TAG=3000BBAA99887766554433221100
TAG=3000BBAA99887766554433221100
TAG=3000BBAA99887766554433221100
TAG=3000BBAA99887766554433221100
TAG=3000BBAA99887766554433221100
TAG=3000BBAA99887766554433221100
TAG=3000BBAA99887766554433221100
TAG=3000BBAA99887766554433221100
TAG=3000BBAA99887766554433221100
...
STOPINVENTORY=0x000A 0x028C

READY>
//Victory!
```

“M” Command Example 2

TODO: Add an example that requires bigger EBV pointer... Yuck.

"P" PROTOCOL control (Gen2 Air protocol)

Description

The reader supports a number of different data rates and modulation modes for communicating with Gen2 RFID tags. This functionality is controlled by the P command.

Read performance is closely tied to how the various modulation, tag signaling and data rate parameters interact in a particular use case. Changes away from recommended settings should be done only after sufficient testing demonstrates an improvement. The best settings are often a compromise between read speed and read reliability.

In some cases it may be beneficial to change this setting to improve performance in multi-reader environments.

Command Group

Radio Control

Command

```
<P>[<PARAMS>]<CR>
...
<P><TARI (0 to 2)><MODE (0 to 3)><LF (0 to 4)>
```

Available Parameters

Value	TARI	Modulation Mode (MODE)	Link Frequency (LF)
0	6.25 uSec	FM0	40KHz
1	12.5 uSec	M2	160 kHz
2	25 uSec	M4	256 kHz
3	-	M8	320 kHz
4	-	-	640 kHz

Recommended Settings TODO: DEFINE

Normal Operation

Dense Reader Environment

High Speed Reads of Small Numbers of Tags

"P" Command Examples

Read the current settings

```
READY>p
AIR PARAMS
TARI=12.5
M=M8
LF=256

READY>
```

Set to 25 uS TARI, Miller 4, 256 kHz LF

```
READY>p222
AIR PARAMS
TARI=25.0
M=M4
LF=256

READY>
```

"R" RF Control

Description

The R command and sub-commands are used to monitor and control radio functions for power and RF frequency. -These commands are used during regulatory testing or under FCC Part 90, licensed operation of the device they are not to be changed outside of the specified limits except by qualified installers.

Command Group

Radio Control

Command

```
<R>[<SUBCMD>[<PARAMS>]]
```

Sub-Commands

Sub Command	Description	Legal Values for SET
RA	RF Transmitter Attenuation Non linear function that controls output power. See below.	Values above the factory default setting for unlicensed operation
RO	Control status of RF Carrier RO1 = OFF RO2 = IDLE RO3 = ON For test use only.	Do not Change. Engineering test function.
RF	Get/Set the Current RF Frequency. RFXXXXX (Five Decimal Numbers) For test use only.	Do not Change. Engineering test function.
RH	Get/Set the Current Hop Dwell Time	Do not

	For test use only.	Change. Engineering test function.

"R" Command Examples

Get and Set

What's the attenuation?

```
READY>ra
ATTENUATION=6
```

Change it!

```
READY>ra3
ATTENUATION=3

READY>
```

Read Frequency

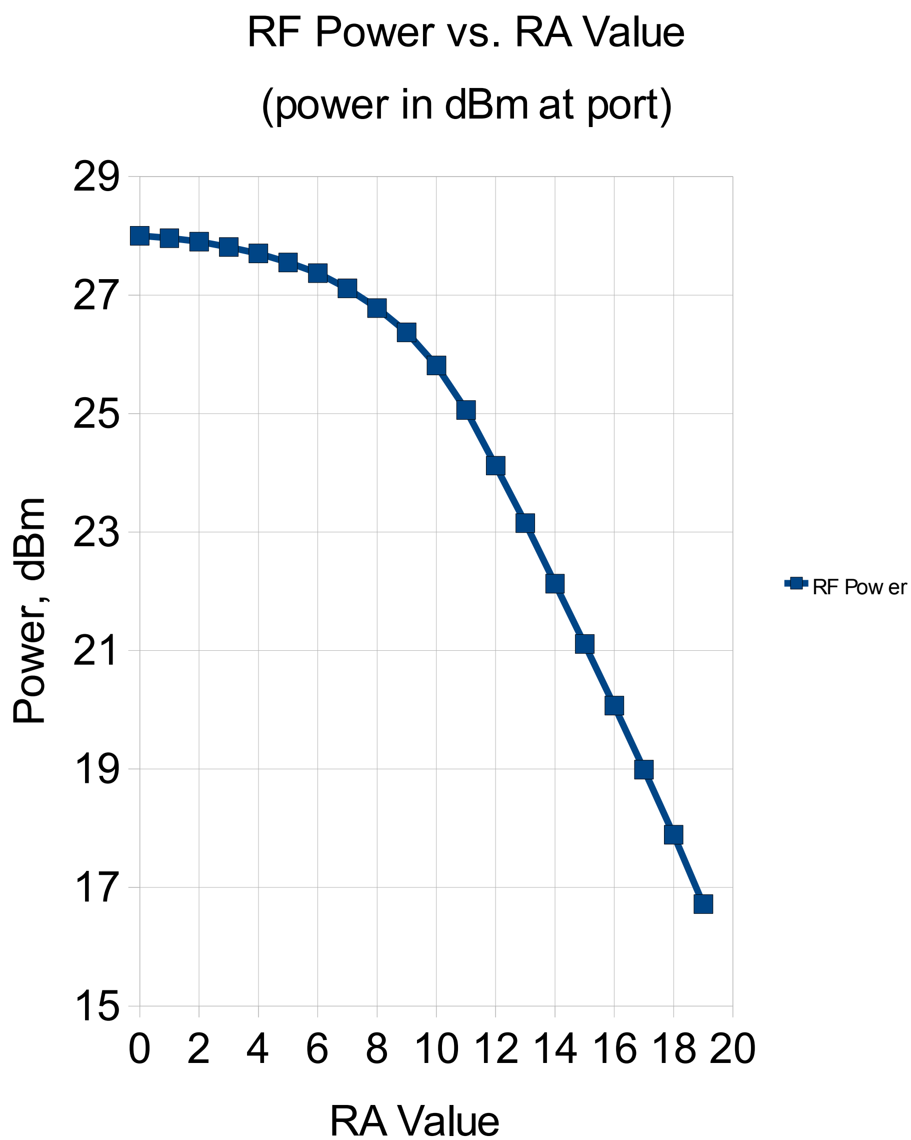
```
READY>rf
FREQ=908250

READY>rf
FREQ=905750

READY>rf
FREQ=920750
```

Set to fixed value

```
READY>rf91525
FREQ=915250

READY>rf
FREQ=915250

READY>rf
FREQ=915250

READY>
```

The RA setting

The RA setting controls power output. – Higher values yield lower output powers. Empirical data yields a curve like this:



In normal, unlicensed operation, the RA value should not be set below its factory default value. (Available via an “RA” command after reader start up.)

"S" Status Functions

Description

The S commands are used to control miscellaneous status functions. The SN family controls reporting of inventories that do not result in tag reads. The SL family allows user applications control of the module LEDs.

Command Group

System

Command

```
<S>[<SUBCMD>[<PARAMS>]]
```

Sub-Commands

Sub Command	Description	Legal Values for SET
SN	Report Status of the “NO TAG” reporting flag	-
SN0	Turns off “NO TAG” messages	-
SN1	Turns on “NO TAG” messages	-
SL	Get the control mode for the LEDS Returns: ManualLED or AutoLED = current LED state	
SLA	Set the LED control to Auto (Sniff, Lock, RF power LEDs under Microprocessor control)	-

SLMX	Set the LED control to Manual (Sniff, Lock, RF power LEDs under program control) and set the state of the LEDs to a the bitmap of X
	`X:`
	`bit0 = LED0`
	`bit1 = LED1`
	`bit2 = LED2`
	`bit3 = LED3`
		0..F

“S” Command Examples

Get and Set

Turn on NOTAG Reporting

```
READY>sn1
NOTAG =ENABLED

READY>t
STARTINVENTORY
TAG=3000E2003412DC03011756040528
TAG=3000E2003412DC03011756040528
TAG=3000E2003412DC03011756040528
NOTAG 915250 01
TAG=3000E2003412DC03011756040528
TAG=3000E2003412DC03011756040528
TAG=3000E2003412DC03011756040528
NOTAG 915250 01
NOTAG 915250 01
NOTAG 915250 01
TAG=3000E2003412DC03011756040528
STOPINVENTORY=0x010F 0x328E
```

LED examples

Check the state

```
READY>sl
AUTOLED=0
```

Set to manual and a value of “A”

```
READY>slma
MANUALLED=A
```

Set to manual and a value of “5”

```
READY>slm5
MANUALLED=5
```

Put back to 0

```
READY>slm0
MANUALLED=0
```

Back to Auto

```
READY>sla
```

```
AUTOLED=0

READY>
```

"T" INVENTORY initiate

Description

Attempt to read tags using the current settings.

NOTE: This section is in progress. Editing and Fleshing out needed!

Command Group

Tag Commands

Commentary

The ISO-18000-6-C (Gen2) protocol specifies a set of low-level commands that can be used to read and write RFID tags. In practice, much of the detail surrounding how this is done is not important to the end user of an RFID system – you just care if the reader reports all the tags and that the data you want to write to them gets written correctly.

That said, some knowledge of what's going on can be used to optimize a system to improve read performance, programming reliability and efficiency. What you want to optimize depends on what you are trying to do with the RFID tags.

In some cases, you want to read a small number of tags very quickly and get lots of repeated reads of the same tag. E.g., an application where you are using an RFID tag on a runner to determine when he/she crosses the finish line of a race. The extra reads here are useful for determining the best “crossing time” for the runner.

In another case, you care less about the number of *redundant* reads and more about the number of *unique* reads you get. An example might be a tool tracking application where you are trying to read all the tagged items within a cabinet and don't want to miss any tags.

To handle these and other cases, you can issue a T command in conjunction with the M, I and X commands to fine-tune what is being reported from the tag field and how the reader interacts with the tag population it sees.

The “T” command

The T command will do a full dual nested loop: SELECT / QUERY / ACK / REQRN / ACK / XREAD / XWRITE sequence, reporting tags as they are found, perform XDATA operations, and attempt to force found tags into the opposite A/B state. All aspects of this command are controlled by the reader's global inventory control parameters (see the “I” command), and the X data descriptor parameters (see the “X” command).

The parameters of the SELECT sequence sent in the OUTERLOOP are fully controllable through the MASKCONTROL commands (see the “M” command). Inclusion, Exclusion, choice of A→B, B→ etc are all under user control.

The global parameters OUTERLOOP, INNERLOOP, SELECTLOOP, and Q can be over-ridden at the command line entry of the command, all other parameters are set globally through the I and X series commands.

If an OUTERLOOP value is set to 0xFF, then the T command will loop constantly, i.e never decrementing outerloop, until a char is received on USB port. The same thing will occur on a T(n) with a loop value of 0xFF (equivalent to no loop value given).

When sending EPC data out the USB, the option is given to append XEPCDATA. This XEPCDATA is instantaneous value when tag acquired of

<FREQ><OUTERLOOP><INNERLOOP><ROUND><SLOTCOUNT><Q>

XEPCDATA may be enabled with a

<I><X><On or Off> command

If, in a T or T(n)command no tags were found a NOTAG message will be sent. In a T this means at every exit from the outer loop, in a T(n) command this means when all slots for the current Q have been tried.

The “Tn” commands:

Tags may also be acquired using the T(n) series of commands. In these commands a minimal series of Air Protocol commands are issued to acquire the tag data. The tags are not removed from the round with a A/B transition, so in general these commands are only useful when the tag population is small.

In all of the T(n) commands, sending the command alone will cause the command to execute repeatedly. and will continue until a character is received over the communication port. If the T(n) command is followed by an additional byte, the command will execute in a loop the number of times specified by the value of the byte.

In each of the T(n) commands the number of slots tried will be determined by the Global Q value. The Masks sent in the commands that include a SELECT will be determined by the valuse in the Global Mask structure array. Any XDATA processing events will be determined by the values in the XDATADESCRIPTOR array.

Note that T1 and T2 modes do NOT send SELECT, so even if masks are active, no masking will occur.

Note that T1,T2,T3,T4 commands ignore any active XDATA DESCRIPTORS

Command

<T1><LOOPCNT (optional)> send a QUERY/QUERYREP/ACK sequence. Number of

QUERYREP is determined by the global Q value.

<T2><LOOPCNT (optional)> same as T1, but each tag reported also reports the RF frequency it was aquired with

<T3><LOOPCNT (optional)> send a SELECT/QUERY/QUERYREP/ACK sequence. Number of QUERYREP is determined by the global Q value.

<T4><LOOPCNT (optional)> same as T3, but each tag reported also reports the RF frequency it was aquired with

<T5><LOOPCNT (optional)> same as T3, but XDATA processing will occur for each tag found (adds REQRN/READ and or WRITE commands)

<T6><LOOPCNT (optional)> same as T5, but each tag reported also reports the RF frequency it was acquired with

Note that a LOOPCNT value of 0xFF is the same as no value - a continuous loop occurs until a char is received on USB

T6 Inventory Return Values...

```
READY>t62
STARTINVENTORY
TAG=30001B1B1111383849495A5A6B6B 913250 35 0 7 Q 5108
TAG=30001B1B11113434445455656767 913250 33 6 3 I 5115
TAG=30001B1B11113D3D4E4E5F5F7070 913250 1E 4 8 Q 5137
TAG=30001B1B111139394A4A5B5B6C6C 913250 0B 6 6 I 514D
TAG=30001B1B111139394A4A5B5B6C6C 924250 3A 9 5 I 516F
TAG=30001B1B1111383849495A5A6B6B 924250 39 6 6 I 517B
TAG=30001B1B11113C3C4D4D5E5E6F6F 924250 37 2 4 Q 5188
TAG=30001B1B11113636474758586969 924250 32 5 5 Q 5196
TAG=30001B1B11113737484859596A6A 924250 13 0 6 Q 51BB
STOPINVENTORY=0x0009 0x00D0
```

Returned fields are:

EPC, Frequency, Slot Count, Imag, Qmag, DecodeChan, TimeStamp

"X" eXtra Data Read and Write Descriptor Control

Description

Anytime an EPC code is acquired, the option exists to either read additional data from the tag, or write data to it. These options are controlled by XDATA descriptors managed by the X commands.

The Thinkify reader maintains four (4) XDATA read descriptors and four (4) XDATA write descriptors that may be individually configured to perform read/write operations.

From RESET all are disabled. When a tag EPC is found each of the descriptors are checked for an ACTIVE condition. If ACTIVE, a read / write at the specified location is performed of specified length and data. Inside the appropriate inventory, (T, T5,T6) the operations will be performed right after the read of the EPC and the data reported in the tag data stream.

Command Group

Tag Commands

Command

```
<X>[<SUBCMD>[<PARAMS>]]
...
<X><R or W><A OR DESCRIPTORNUM 1 nibble (0 to 3)>[ACTIVE][<PARAMS>]
```

Flags

<PARAMS>

[#] – Descriptor number

[ACTIVE] – Descriptor enabled

[MEMBANK] – Tag memory bank for the operation

[LEN] – Length (in words) of data to be read/written

[EBV] – EBV pointer into memory for the start of the operation

[DATA] – Bytes to be written.

Sub-Commands

Sub Command	Description	Legal Values for SET
XR	Report all XDATA read descriptors	-
XRR	Reset all XDATA read descriptors	-
XR[#]	Report a given XDATA read descriptor	0..3
XR[#][ACTIVE]	Control Active flag for XDATA read descriptor [#]	0..1

XR[#][ACTIVE][...]	When a tag EPC is found each of the 4 descriptors are checked for Active condition. If active, a read at the specified location is performed of specified length.
	`XR[#][ACTIVE][MEMBANK][LEN][EBV (up to 4)]- Full control of a read descriptor`
	
	`[MEMBANK] = 0..3`
	`[LEN] = 1..8 Number of words to read`
	`[EBV] = Word pointer into memory. 1-4 Bytes.`
		See Description

XWR	Reset all XDATA write descriptors	-
XW[#]	Report a given XDATA read descriptor	0..3
XW[#][ACTIVE]	Control Active flag for XDATA write descriptor [#]	0..1

XW[#][ACTIVE][...]	When a tag EPC is found each of the 4 descriptors are checked for Active condition. If active, a write at the specified location is performed of specified length with DATA provided.
	`XW[#][ACTIVE][MEMBANK][LEN][EBV (up to 4)]- Full control of a read descriptor`
	
	`[MEMBANK] = 0..3`
	`[LEN] = 1..8 Number of Words to write`
	`[EBV] = Word pointer into memory. 1-4`
		See Description

Sub Command	Description	Legal Values for SET
	Bytes. [DATA] = Data to write to the location	

“X” Command Examples

Example 1

Read extra data in an inventory.

```
//Read a tag w/ Default parameters.
READY>t
STARTINVENTORY
TAG=3000E2003411B802011029356733
STOPINVENTORY=0x0001 0x004A

//set descriptor 0 to read BANK 1 LENGTH 4 WORDADDRESS 02
READY>xr011402
RDDESCRIPTOR=0
ACTIVE=1
BANK=1
LEN=4
PNTR=02

//Look for the extra data
READY>t
STARTINVENTORY
TAG=3000E2003411B802011029356733
XRD0 E2003411B8020110
STOPINVENTORY=0x0001 0x0039
//Victory!
```

Example 2

Use the T6 command with 0x10 iterations to read the data requested in the descriptor above.

```
READY>t6A
STARTINVENTORY
TAG=3000E2003411B802011029356733 924250 05 E B I 1FBF
XRD0 E2003411B8020110
TAG=3000E2003411B802011029356733 926750 00 E C Q 1FF0
XRD0 E2003411B8020110
TAG=3000E2003411B802011029356733 926750 02 E C Q 2007
```

```
XRD0 E2003411B8020110
TAG=3000E2003411B802011029356733 926750 06 E C I 201E
XRD0 E2003411B8020110
TAG=3000E2003411B802011029356733 926750 02 E C I 2038
XRD0 E2003411B8020110
TAG=3000E2003411B802011029356733 926750 06 E C Q 204F
XRD0 E2003411B8020110
TAG=3000E2003411B802011029356733 926750 05 E C Q 2068
XRD0 E2003411B8020110
TAG=3000E2003411B802011029356733 926750 03 E C I 2081
XRD0 E2003411B8020110
STOPINVENTORY=0x0008 0x00DB
```

Example 3

Set write descriptor to write 3 words with data AABBCCDDEEFF to bank 1 word 2 and write it into a tag.

```
//1st read a tag
READY>t
STARTINVENTORY
TAG=3000E2003411B802011029356733
STOPINVENTORY=0x0001 0x0034
//Set up to rewrite a portion of the EPC
READY>xw011302AAAABBBBCCCC
WRDESCRIPTOR=0
ACTIVE=1
BANK=1
LEN=3
PNTR=02
WRITE DATAAAAABBBBCCCC
//Read the tag again and perform the write operation
READY>t
STARTINVENTORY
TAG=3000E2003411B802011029356733
XWR0 WRITE SUCCESS
STOPINVENTORY=0x0001 0x005E

//Read again and we see the new EPC
READY>t
STARTINVENTORY
TAG=3000AAAABBBBCCCC011029356733
XWR0 WRITE SUCCESS
STOPINVENTORY=0x0001 0x003C

READY>
//Victory!
```

Example 4

You can use a T6 inventory command with 0xA iterations to perform the write - write proceeds partially if it cannot be completed in one operation. The WRITE success operation is given when all data matches the requested write field. Once the data matches all XWR messages will indicate success with no further actual write attempts.

Any XREAD or XWRITE that does not complete successfully will return an error code. Note that in the case of a WRITE, some portion of the WRITE may complete and still return an error code, if multiple word writes are requested. Also note that in the case of a WRITE an error code will be generated if the ASYNC response from the tag is improperly decoded, although the WRITE may have worked.

```
READY>xw011402111122223333334444
WRDESCRIPTOR=0
ACTIVE=1
BANK=1
LEN=4
PNTR=02
WRITE DATA=1111222233334444
```

```
READY>t610
STARTINVENTORY
//First inventory loop
TAG=3000AAAABBBBCCCC011029356742 919750 07 C E Q CB2D
XWR0 WRITE SUCCESS
//Next loop shows new id.
TAG=30001111222233334444429356742 919750 05 C E I CB83
XWR0 WRITE SUCCESS
TAG=30001111222233334444429356742 919750 00 C E I CBC5
XWR0 WRITE SUCCESS
TAG=30001111222233334444429356742 919750 07 C E I CBE4
XWR0 WRITE SUCCESS
TAG=30001111222233334444429356742 919750 03 C E Q CC07
XWR0 WRITE SUCCESS
TAG=30001111222233334444429356742 919750 01 C E I CC29
XWR0 WRITE SUCCESS
TAG=30001111222233334444429356742 919750 00 C E I CC4E
XWR0 WRITE SUCCESS
STOPINVENTORY=0x0007 0x014F
//Victory!
```

Example 5

SET a write descriptor, then GET it

```
READY>xw01140211112222333334444
WRDESCRIPTOR=0
ACTIVE=1
BANK=1
LEN=4
PNTR=02
WRITE DATA=1111222233334444

READY>xw0
WRDESCRIPTOR=0
ACTIVE=1
BANK=1
LEN=4
PNTR=02
WRITE DATA=1111222233334444
```

Appendix A. Using the Thinkify Firmware Update Utility

From time to time, Thinkify will issue upgrades to the reader firmware that add new features, improve performance or fix issues we uncover.

These upgrades are distributed as a special file with a .hex extension. .hex files are named with the following format:

```
PIC_YYMMDD_MmR.hex
```

Where:

```
YY = Year
MM=Month
DD=Day
M=Major version number
m=Minor version number
R=Revision number
```

To Upgrade your reader, place it into bootloader mode and then use the firmware upgrade utility to install the file. (See the Bootloader command)

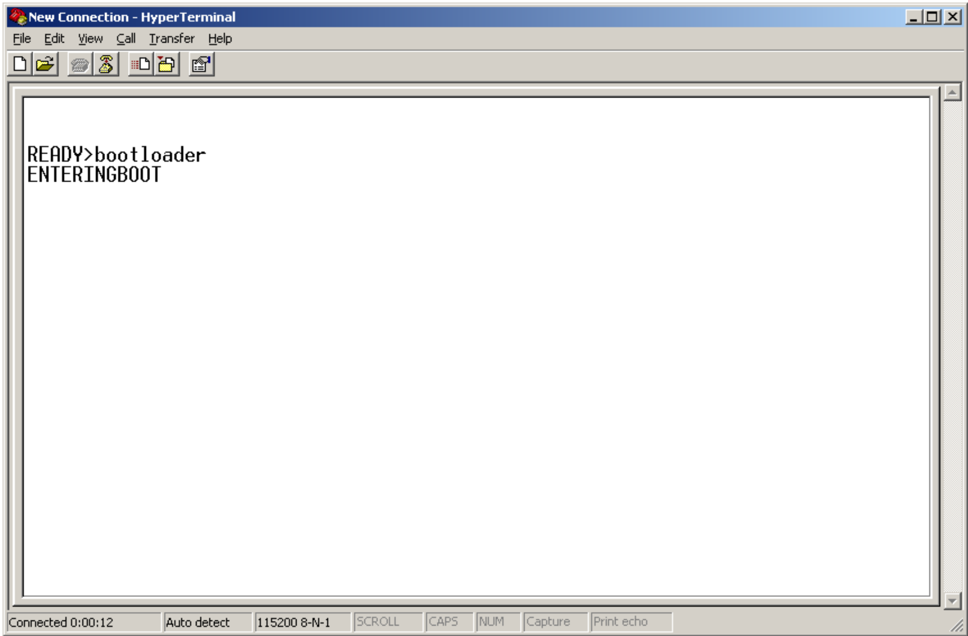
From Hyperterminal or TeraTerm, Type:

```
bootloader<cr>
```

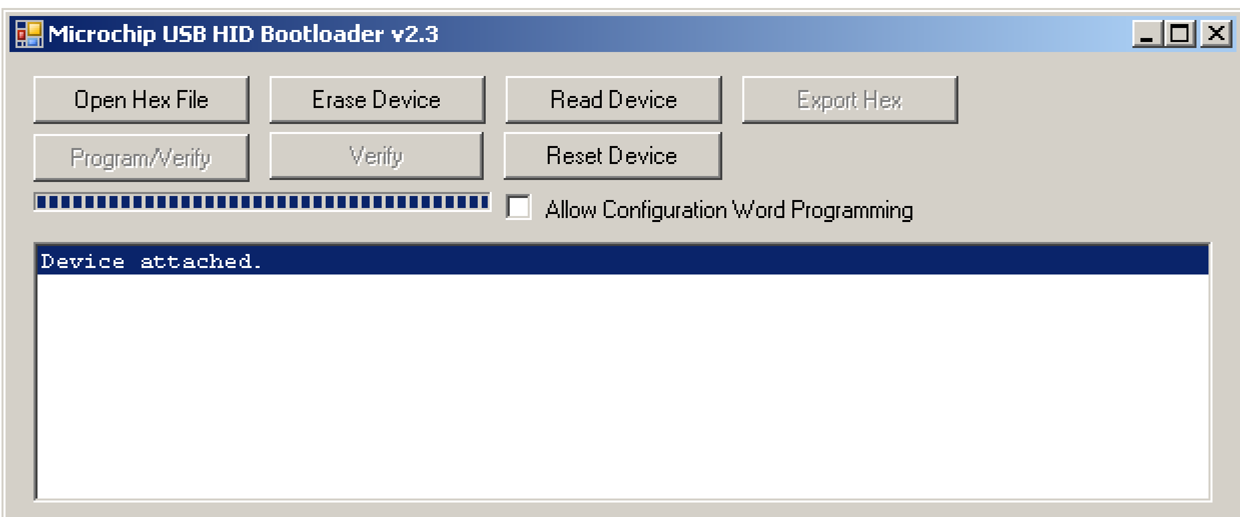
at the

```
Ready>
```

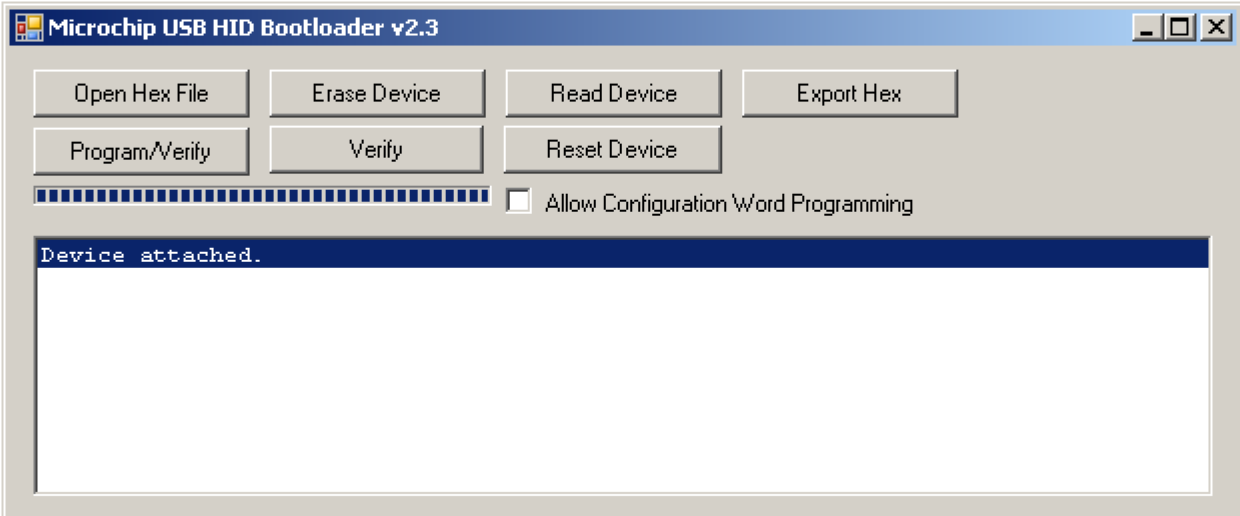
prompt. You should see a message that the reader is entering bootloader mode. Once in that mode, the reader will no longer respond to regular commands until it is reset. Two of the LEDs on the front of the unit will rapidly flash back and forth indicating that the reader is waiting for a firmware upgrade.



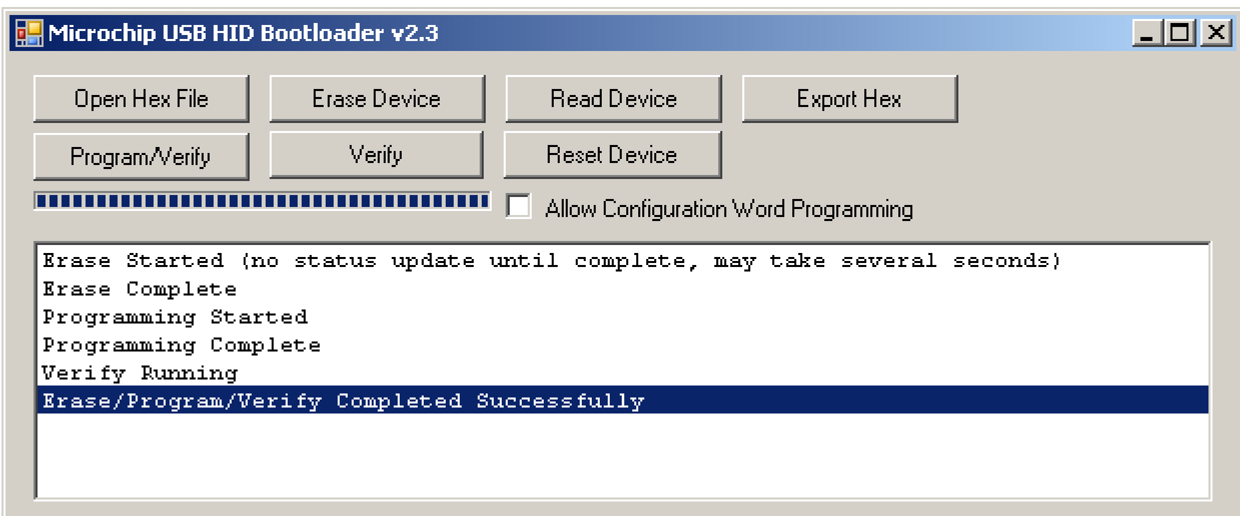
(LEDs are now flashing) Close Hyperterminal and open the firmware update utility.



You should see a message that the program has detected the device: “Device attached.” Click “Open Hex file” and select the firmware upgrade file from the file manager window:

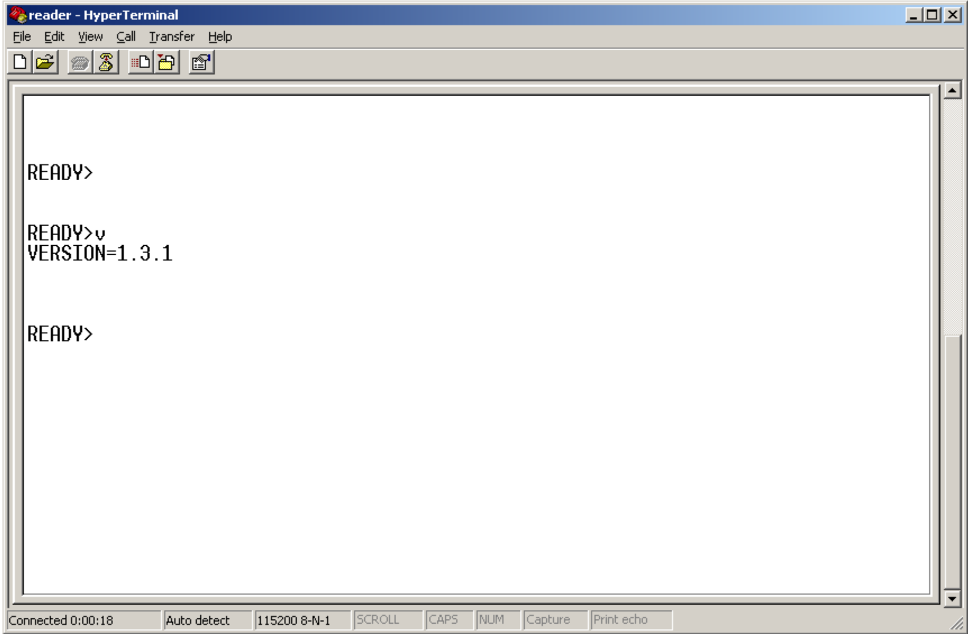


At this point Click the “Program/Verify” button to start the upgrade.



The program will erase the old firmware, install the new firmware and verify that the installation went ok. Click the “Reset Device” button to take the reader out of bootloader mode and note that the upgrade utility detected that the device has been removed.

Close the upgrade utility, and restart Hyperterminal. Using the “v” command you can verify your new firmware version:



Congratulations! You've been upgraded...

Appendix B. GPIO Port

PENDING...