CCD Camera HTTP Server User's Manual

9596 Rev. A

Spectral Instruments, Inc.

TUCSON, ARIZONA

* Notes and Warnings

1. The AC-DC power supply operates on incoming main voltages from 100V to 240V AC at 50/60 Hz, with a maximum fluctuation of plus or minus 10%. The equipment is intended to be used in an installation category II, pollution degree 2 environment.

* Warnings

1. This equipment uses a laser to drive the fiber optic data communications port on the controller. Do not inspect the laser output while it is powered on. Use of controls or adjustments of performance or procedures other than those specified herein may result in injury.

   The CCD Camera HTTP Server employs a laser-based transceiver which is certified as Class 1 Laser Eye Safe when operated in accordance with normal operating conditions as specified herein.

2. Do not look into the transceiver unit.

Service Requirements

1. **There are no user serviceable components in a P/N 9488 CCD Camera HTTP Server.**

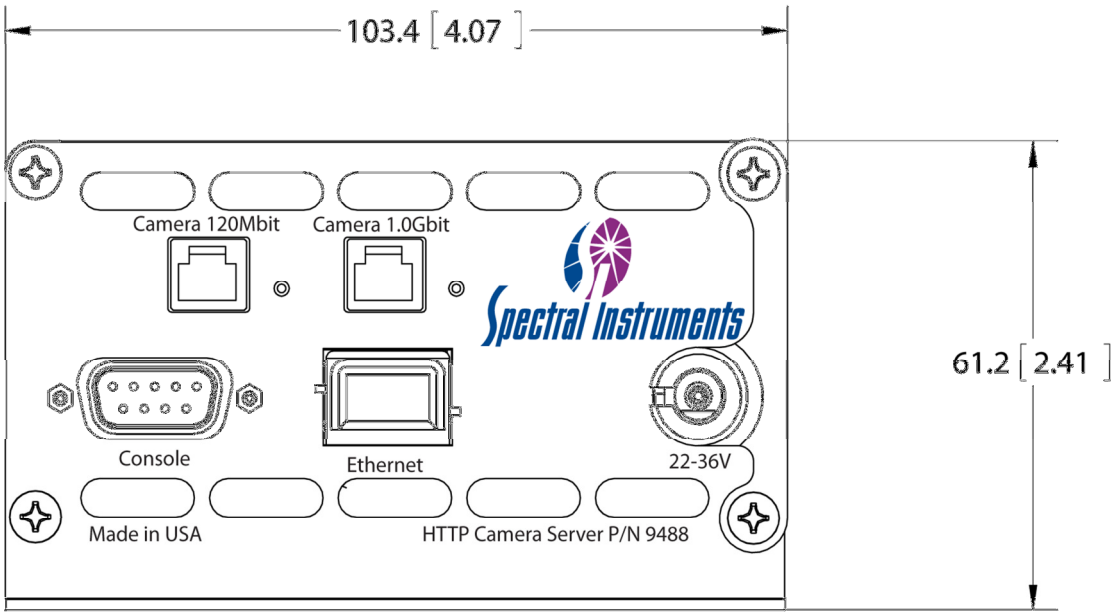
Introduction

Spectral Instruments CCD Camera HTTP Server provides an Ethernet interface for a Spectral Instruments camera. The device is a HTTP compliant server that listens for connections to TCP/IP port 80 on its Ethernet interface. The Ethernet interface supports Dynamic Host Configuration Protocol (DHCP).

The CCD Camera HTTP Server is capable of providing camera control over domains from local to global. It can be controlled by a web browser, Spectral Instruments proprietary SI Image software, or custom programs. Custom programs can access the server using Spectral Instruments camera control library or directly via sockets programming with Berkley sockets (on Linux) or the Winsock library (on Microsoft Windows). Spectral Instruments part number 8997 is the camera control library SDK, that supports both Linux and Microsoft Windows.

The CCD Camera HTTP Server has an image buffer that can receive and hold an image from the camera. In the event that power is removed from the server or the server is reset, the image in the buffer is lost.

The Server, depicted in Figure 1, provides 511 Mbytes of image storage and affords complete control through its Ethernet connection. There is an auxiliary serial port (DB-9) called 'Console', to allow initial setup of the Ethernet configuration.



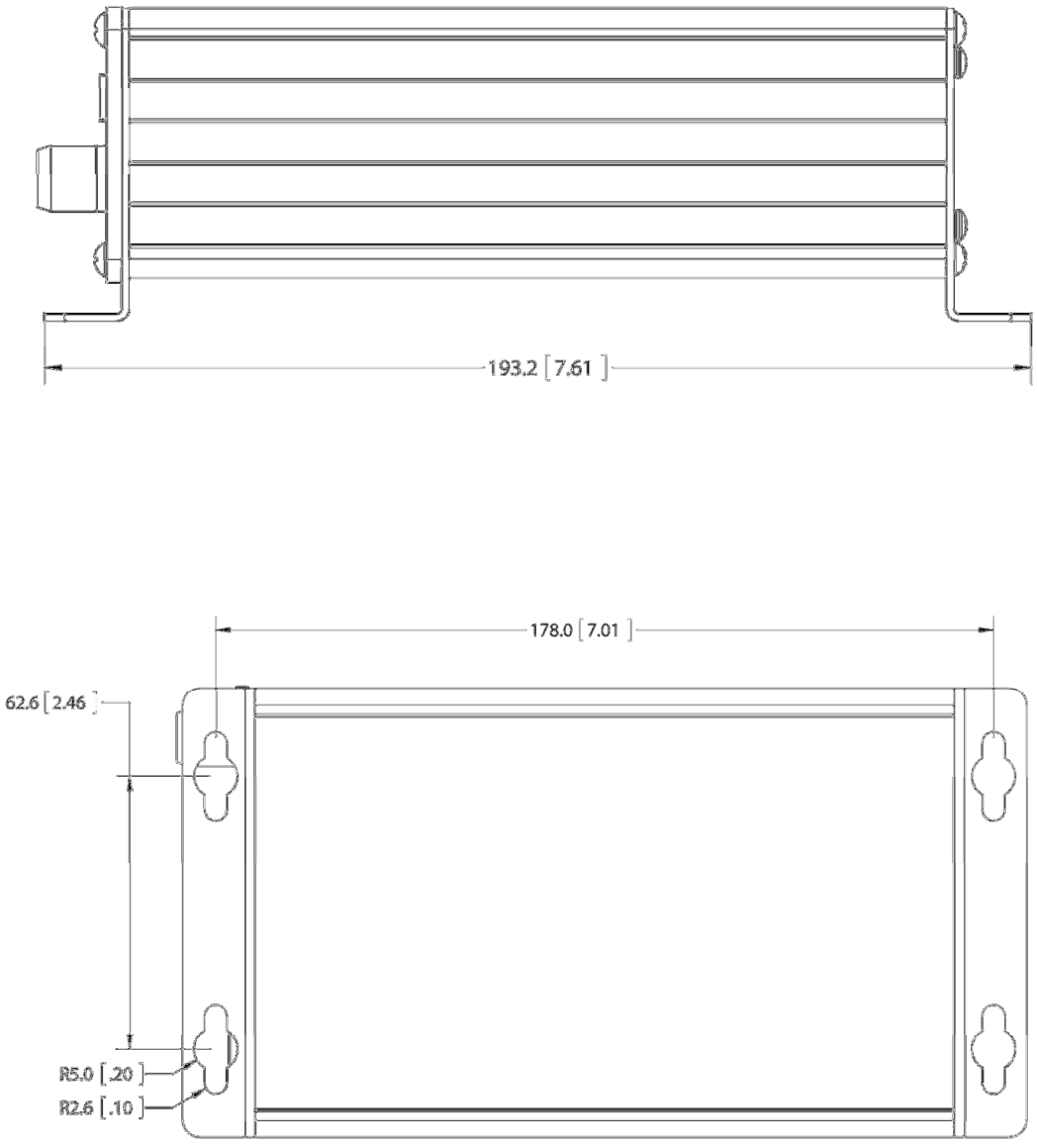


Figure 1

The unit is powered by a 24V DC power supply (refer to the service manual, Spectral Instruments part # 9595, for exact specifications). This power adapter is supplied with a 5-foot DC cord that plugs into the power entry receptacle on the server. The adapter is rated at 100-240V 50/60 Hz input and provides 24V DC as its output. It is supplied with an incoming AC power cord that has a U.S. AC Mains connector.

The CCD Camera HTTP Server communicates with cameras that use the G2/G4 command set. The 1110 camera uses a XML command structure and does not operate with the CCD Camera HTTP Server.

Initial Setup

The server is shipped with DHCP enabled. If this is not acceptable, set the IP address, network mask and gateway to be compatible with the local network to which the server will be connected.

The serial port console (DB-9) is configured to operate at 115,200 Baud, 8 data bits, 2 stop bits, no parity. It can be connected to a standard PC serial port using a straight-through DB-9F to DB-9M cable. This is compatible with most USB to serial bridge devices for computers that do not have a built-in serial port. A variety of options are available for communicating with the server through the serial port. The most likely is a USB to serial port adapter that can be purchased at any number of electronics supply outlets. Such an adapter also requires support for a driver that is obtained over the Internet and a terminal emulating application that is also available over the Internet.

Appendix A lists available serial port (and local Ethernet) commands. When given an "enter", (RET), character the module responds with a ">" prompt. The first useful command might be "?" which lists the commands with a brief description of each.

To configure the network settings, begin by entering "IPCONF" and then press the enter key. This command displays the IP address, network mask, default gateway, and MAC address in use by the server.

Enter "IPADDR" with a suitably formatted IP address (spaces replacing the traditional decimal points) then press the enter key. Then enter "NETMASK" with similarly formatted parameters to set the network mask. Finally enter "GATEWAY" with similarly formatted parameters to set the default gateway. Each of these commands will display the octets of the address or mask you have entered. If the value displayed is not what you intended, check your typing. Be sure to not enter periods '.' as part of the parameters for these commands.

Once the "IPADDR", "NETMASK", and "GATEWAY" commands have been completed, the "FLASH" command needs to be issued to record these values in the non-volatile storage of the server. Finally, the server needs to be power cycled or reset to reconfigure the server to use the IP address, network mask, and default gateway that were recorded in non-volatile storage. A reset can be accomplished by issuing a "SYSRST" command.

The CCD Camera HTTP Server as a Camera Interface

The CCD Camera HTTP Server communicates with Spectral Instruments' two types of fiber-optic cameras using its two MT-RJ ports. The high-speed (gigabit) port has a metal shell. The slow speed (120 Mbit) port has a black plastic shell.

The server auto-detects the operating speed and duplex mode of the Ethernet connection and adjusts accordingly. There is no need for a crossover cable as the Ethernet connection automatically adjusts to MDI or MDI-X as required.

All fiber-optic cameras manufactured by Spectral Instruments with model numbers higher than 620 using the G2 and G4 command sets are supported. These cameras have a fiber optic data

connection that utilizes a 2-fiber multi-mode cable with MT-RJ connectors on each end. Older cameras' fiber optic speed is 120 Mbits per second while later cameras communicate at a speed of 1 gigabit per second. Each port on the Server is accompanied by a small green LED indicator that, if lit, indicates connection with the camera head. It is necessary that the port type used on the server match that on the camera.

Having assigned the CCD Camera HTTP Server a suitable IP address, it is prepared to accept Ethernet commands that are passed on to the camera, receive data streams from the camera, and to respond to client program requests. Sending the camera a command typically results in a response. Responses from the camera modify data within the server that modifies the content of the files the server can provide.

Data is sent to the server as standard HTML form submissions. This allows web browsers to operate the camera. The server decodes the data from the forms into camera commands and transmits those commands to the camera. The camera typically acknowledges the commands and sends responses to the server. These responses are made available using XML files the server can provide. Some of the HTML pages include Asynchronous JavaScript and XML (AJAX) to allow the XML data produced by the server to be displayed using a web browser that supports that protocol. Appendix B illustrates camera control through the Server using a web browser.

Custom Programming:

Custom programs operating the camera through the server will need to send data in a manner compatible with HTML forms. This is described in the sections below. The XML data can be downloaded from the server using standard HTTP requests for the various XML files provided. Various other file types are provided as mentioned in the body of this document, allowing custom programs to access additional data.

It is not necessary for custom programs to interpret HTML pages to control the camera. It is necessary for custom programs to interpret XML data files. There are some plain text files that it would be convenient for custom programs to interpret as well.

Text to be sent to the server will be presented in C/C++ source code format: "\t" represents a tab (0x09), "\r" represents a carriage return (0x0D), and "\n" represents a line feed (0x0A). All XML data provided by the CCD Camera HTTP Server comply with the Spectral Instruments, Inc. "Camera Control XML Database User's Manual," part number 6762.

Discovery of CCD Camera HTTP Servers on a Local Ethernet segment:

In order to communicate with a server, it is necessary to know its IP address. This section describes a programmatic method to discover the IP address of any Spectral Instruments, Inc. CCD HTTP Camera Servers connected to your local network.

The CCD Camera HTTP Server will respond to a broadcast UDP datagram and identify itself. Any firewall program on your computer must be set up to allow incoming access to UDP port 49344 (for UDP image transfers and/or device discovery) and outgoing access to port 49601 (for UDP image transfer requests) and port 49858 (for device discovery). To find devices that are connected to an Ethernet segment do the following:

- Identify the IP address and subnet mask of your client program's local connection to the Ethernet segment that contains the server you are seeking. For example, the IP address "192.168.0.1" normally has "255.255.255.0" as its subnet mask.
- Replace the bits in this IP address with a 1 for each bit that is zero in the subnet mask. This is the broadcast address for that subnet. For the example above "192.168.255.255" would be the broadcast address.
- Create a thread listening to UDP port 49344.
- Send a UDP datagram to the broadcast address and port 49858 that contains: "Spectral Instruments, Inc.\r\n49344" and no other text.

Each Spectral Instruments, Inc. CCD Camera HTTP Server on the subnet will respond with a UDP datagram sent to port 49344 that contains "Spectral Instruments, Inc.\r\nI#\tSIController-M#" where I# is the IP address and M# is the decimal representation of lower 24 bits of the MAC address of the server. "SIController-M#" is the server name provided by the server in all HTTP transactions.

Please note that every server on the subnet will respond. It is necessary to collect all the responses, not just the first one. This data can be used to provide the user with a list of servers from which they can select the one they wish to use.

Controlling the CCD Camera HTTP Server with Custom Programs

The CCD Camera HTTP Server has the ability to store configuration files in its internal FLASH. This allows the server to work with a small number of DSP codes without uploading the configuration file. This will only work if the camera plugged into the server has DSP code that corresponds to a loaded configuration file.

In this section, HTTP headers are omitted from the server responses. The form of a typical HTTP header from the server is "HTTP/1.0 200 OK\r\nServer: SIController-M#\r\nContent-Type: text/html\r\nContent-Length: ### \r\nCache-Control: DIRECTIVE\r\n\r\n". Where M# is the decimal representation of lower 24 bits of the MAC address of the server, ### is the number of bytes in the data following the header, and DIRECTIVE is an HTTP cache control directive. The text "\r\nRefresh: #" may be inserted directly before the final "\r\n\r\n" if the page is intended to

be re-drawn by a web-browser at some interval (such as "\r\nRefresh: 1" for ACQ.HTM). The Content-Type specified will vary for files that are not HTML.

In most cases, custom programs will want to load the file "/command.txt" immediately after posting HTML form data to the server. This allows the programs to directly inspect the results of applying the commands, including any error messages from the command interpreter.

Sending HTML form data to the server:

Commands can be sent to the server using the standard method for submitting HTML forms. This requires that the commands be of the form "COMMAND=DATA" or "COMMAND." Note that HTML forms will always be of the first form. The second form will be recognized by the server, but never generated by an HTML form. Multiple commands can be sent to the server in a single TCP/IP packet. To do so, they must be separated by the "&" character. The text "SETUP_3=1&SETUP_5=1225" is an example of a multi-command submission that changes two setup parameters simultaneously.

An HTTP header must be supplied specifying the file you wish to receive and the length of the payload of the posted packet. This can be done using the following lines in a Python 3.5 program (Request produces the HTTP header automatically):

```
from urllib.request import Request,urlopen
req=Request("http://192.168.0.223/command.txt",b"SETUP_3=1&SETUP_5=1225")
print(str(urlopen(req,timeout=5),encoding="utf-8"))
```

A C or C++ program will need to produce the HTTP header. This would be of the form: "POST /command.txt HTTP/1.0\r\nAccept: */*\r\nContent-Length: #\r\n\r\n" where "#" would be replaced by a text string representing the length of the payload. In the example above it would be "22" (two ASCII characters 0x32).

Any command from the Host Port Command Set listed in appendix A can be sent to the server by this method. Note that many of the commands require arguments in addition to the new value. The commands to set the camera parameters are included in the XML files that describe the parameters. Refer to the "Camera Control XML Database User's Manual," part number 6762 for further details.

Retrieving XML (or other) data files from the server:

If your program needs data from the camera but does not wish to issue any commands, an HTTP GET request can be used to download any file that exists on the server. An HTTP header must be supplied specifying the file you wish to receive. This can be done using the following lines in a Python 3.5 program (Request produces the HTTP header automatically):

```
from urllib.request import Request,urlopen
req=Request("http://192.168.0.223/files.xml")
print(str(urlopen(req,timeout=5),encoding="utf-8"))
```

A C or C++ program will need to produce the HTTP header. This would be of the form: "GET /files.xml HTTP/1.0\r\nAccept: */*\r\n\r\n".

The file "files.xml" is a list of all the files that are available from the server. It is a useful place to start gathering data. Note that each file also has attribute tags in the XML. These tags provide

information about the type of data included in each file. Many of the tags contain a zero ('0') or a one ('1'). The attribute is "false" when the value is zero and "true" otherwise. The following tags provide information of interest in determining how to use the information in the files to control the camera:

- The <parameter> tag indicates that the file contains camera control parameters.
- The <status> tag indicates that the file contains camera status parameters.
- The <command_file> tag indicates that the file contains camera command descriptions.

The <Content-Type> tag contains a string indicating the MIME type of the file. The string "text/xml" indicates an XML file.

Retrieving image data using UDP datagram transfers:

It is not required that custom programs use UDP datagrams to transfer image data. Images can be retrieved using a standard HTTP GET request. The primary advantage of the UDP transfer is that it can be significantly faster than an HTTP GET request. In addition, the UDP transfer can occur during image readout. The HTTP GET request needs to wait until readout has completed. These advantages make the UDP datagram transfer method preferred if high image throughput is required.

In order to initiate a UDP image transfer, the application needs to send a UDP datagram requesting image data. This datagram needs to be sent to port 49601 at the CCD HTTP Camera Server's IP address. The local port your application uses should be one of the ephemeral port numbers in the TCP and UDP ports. The format of this datagram is as follows (note that all 4 byte numbers are in network byte order):

```
Index 0   'S'
Index 1   'I'
Index 2   'R'
Index 3   a byte containing the number of request blocks.
Index 4   4 bytes indicating the frame number for the request.
Index 8   request block 0 (8 bytes).
Index 16+ may contain additional request blocks (a maximum of
          183 request blocks in a single datagram).
```

Note that the request blocks must be sorted in ascending order by offset. For efficiency, a single UDP request can contain up to 183 request blocks. The format of each request block is as follows:

```
Index 0   4 bytes indicating the byte offset within the image.
Index 4   4 bytes indicating the number of bytes to send.
```

The server will echo the datagram sent back to your application. The echo datagram will come to UDP port 49344. If any request block contained a request that could not be fulfilled, the number of bytes for that request will be set to zero by the server. The echoed datagram should be inspected to be sure that the requests can be fulfilled.

Immediately after processing the datagram, the server will begin sending image data. Your program can issue a new request during the image download. This accommodates retransmission

of lost datagrams. With UDP transfers your application must keep track of which data are received and which are missed. Your application must issue requests to re-transfer any data that are missed. It may be necessary to request a particular datagram more than twice.

Each datagram containing image data will be of the form (note that all 2 or 4 byte numbers are in network byte order):

```
Index 0   4 bytes indicating the byte offset within the image.
Index 4+  2 bytes for each pixel (a maximum of 734 pixels in a
          single datagram).
```

.

Appendix A

HTML Form Command Set

These commands may appear in HTML form submissions or be entered through the console port.

Command	Description
?	Display this help text.
ABORT	Abort an exposure or readout.
ACQUIRE	Acquire an image.
BAUD	Get/set the camera Baud divisor.
CAMRESET	Reset the camera.
CAMRSTRT	Restart the camera.
CFGFILE	Display the active configuration file name.
CLEAR	Get/set the continuous clear mode.
CLRFRAME	Clear the CCD.
CONTROL	Get/set the control table.
COOLER	Get/set the cooler enable.
ERASE	Deletes configuration data in FLASH.
FACTORY	Display the factory table.
FLASH	Records configuration data in FLASH.
GATEWAY	Get/set the default gateway.
G2MODE	Get/set the mode algorithm (3=G3,4=G4).
HELP	Display this help text.
IPADDR	Get/set the IP address.
MODEDEL	Delete the mode at [INDEX].
MODEGET	Read the mode from [INDEX].
MODEMASK	Display the mode mask.
MODESET	Save the mode to [INDEX].
MS_LEFT	Display the remaining exposure milliseconds.
NETMASK	Get/set the Subnet Mask.
OPSTAT	Display the operational status.
READLIN	Get/set the linearity readout enable.
READTE	Get/set the TDI externally paced readout enable.
READTI	Get/set the TDI internally paced readout enable.
READTRG	Get/set the triggered readout enable.
READTST	Get/set the test readout enable.
SETUP	Get/set the setup table.
SHUTTER	Get/set the shutter control.
STATUS	Display the status table.
SYSRST	Initiate a system reset.
VERSION	Display the version of this software.

Console (DB-9) Command Set

These are service/maintenance commands that should only be used by qualified service personnel (except as noted in the "Initial Setup" section of this manual). ***Improper use of these commands can render your system non-functional.*** The commands in the HTML Form Command Set are also accepted by this interface.

"\r\n>" is the command prompt

Notes about special controls (line editing features) of the console:

ESC	(Escape) will terminate line entry and print the command prompt.
'\r'	(Enter) will execute the command.
'\n'	(CTRL-J) Retype and execute the previous command.
'\t'	(TAB) Retype the previous command.
'\b'	(BACKSPACE) will back up one character.
$	indicates a hexadecimal number ($F is 15 decimal).
%	indicates a binary number (%111 is 7 decimal).

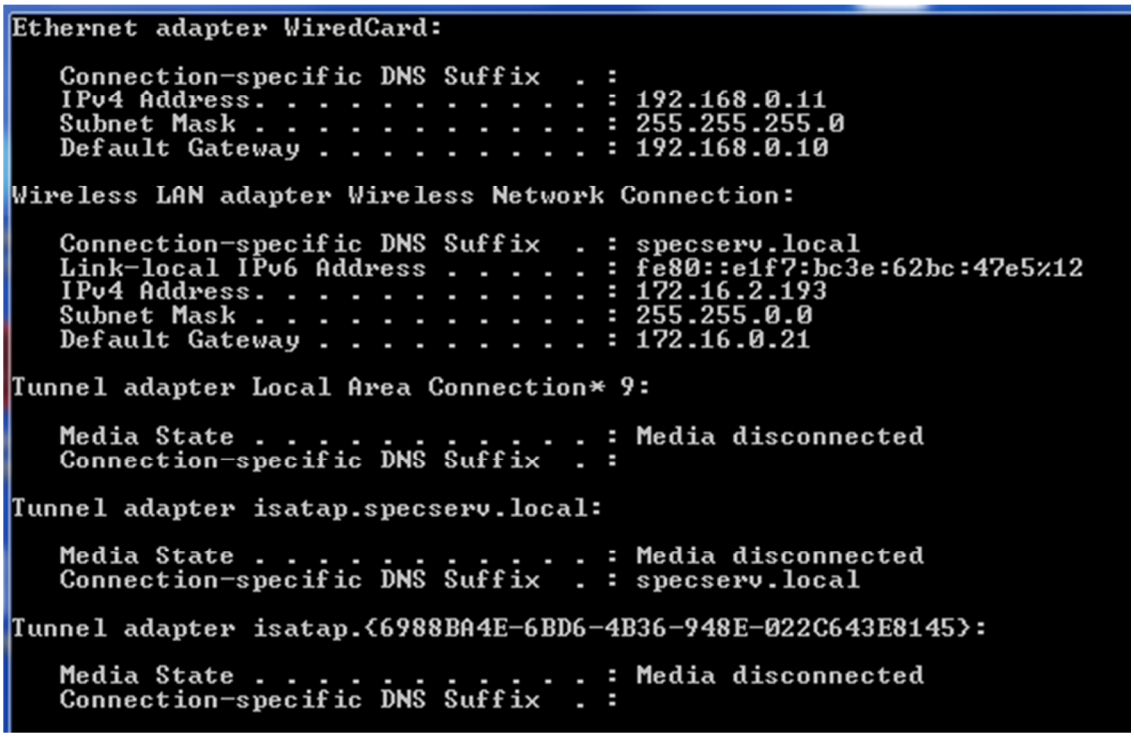
Command	Description
?	Display this help text.
BIOS	Force a reset to the BIOS command prompt.
COMCAP	Display the command capability mask.
G2CP	Get/set the G2 configuration.
G2RFP	Get/set the G2 readout and format.
G2SP	Display the G2 status.
GET	Display a file.
HELP	Display this help text.
HOST	Let the HTML form command parser process the command.
IPCONF	Display the IP configuration.
IPSTATS	Display the IP statistics.
MEZZ	Forward a command to the mezzanine interface card.
PWM	Get/set the fan PWM register.
SYSSTAT	Display the system status.

Troubleshooting

2018_7_08 Maintenance Notice:

At Spectral we discovered that running a windows update made an on-the-motherboard Ethernet connection disappear.

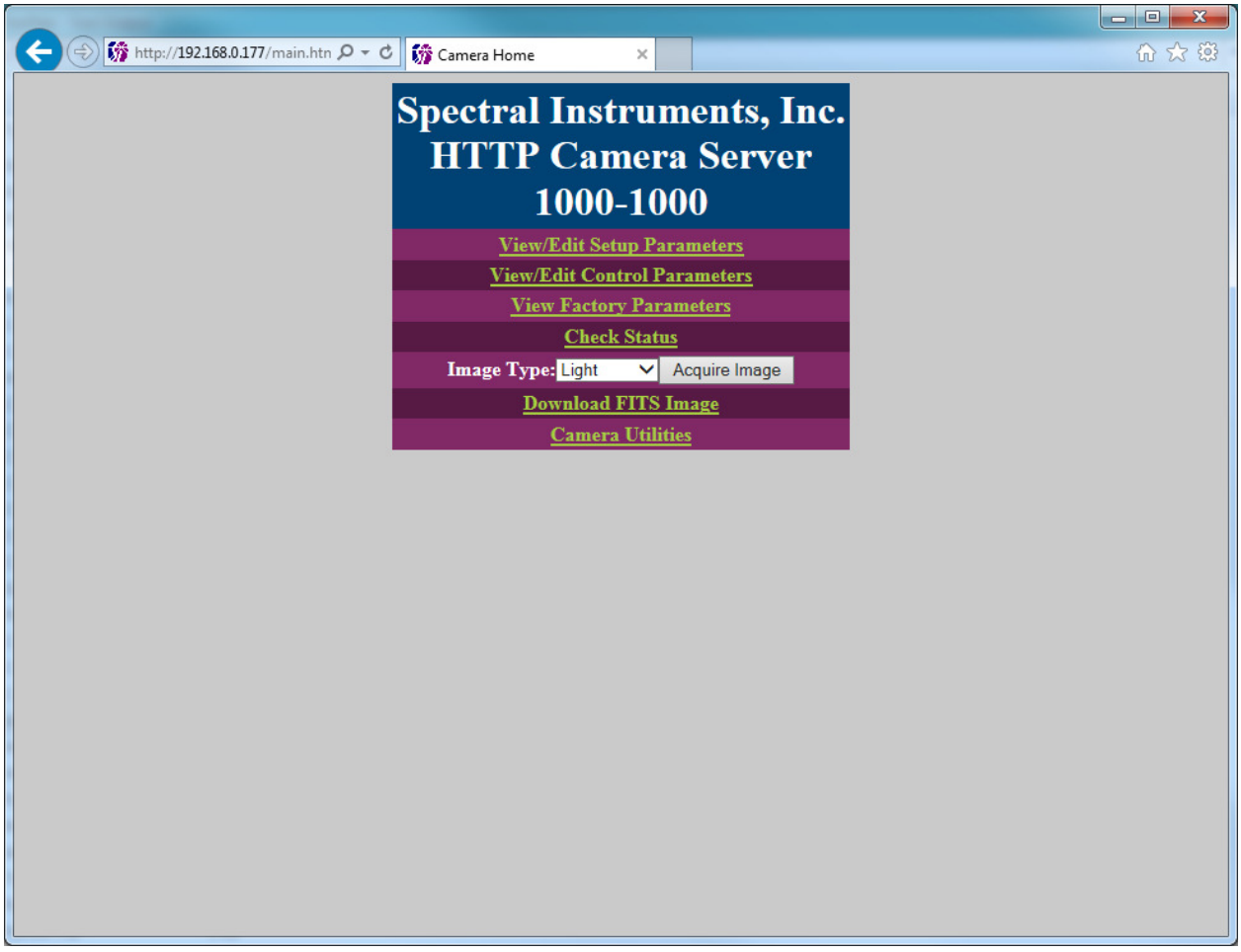
To check that Ethernet is actually running on the Windows PC, from the cmd line enter ipconfig and you must find a suitable Ethernet connection or else you will not be able to communicate with the CCD Camera HTTP server. In the clip shown below, the Ethernet adapter WiredCard: or some equivalent must show up to indicate that your Ethernet is alive and that an Ethernet cable is plugged in



Appendix B
Operating the CCD Camera HTTP Server with a Web Browser.

Main.htm:

If you direct a web browser to load the CCD Camera HTTP Server's address, the following page will be displayed:

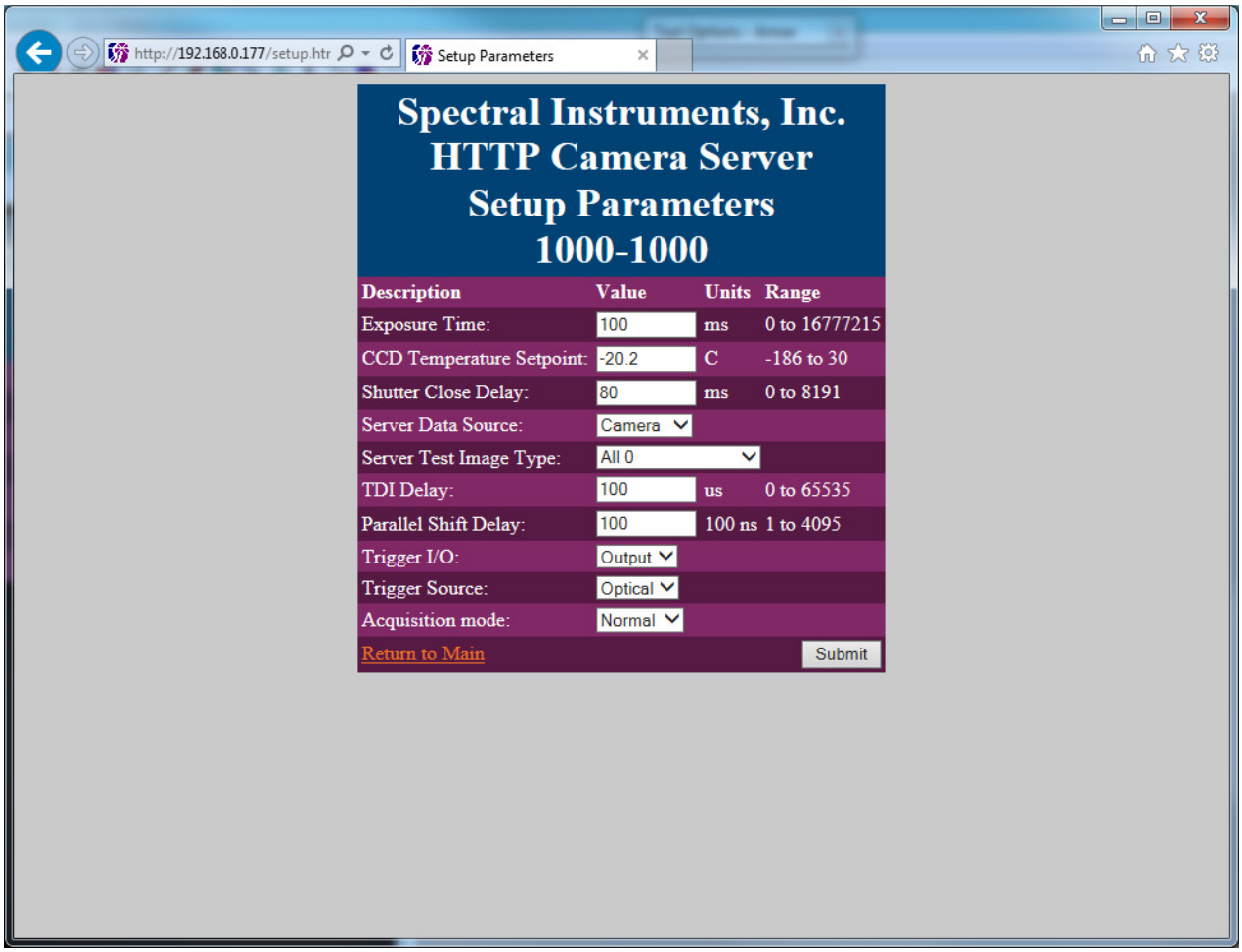


There are several links to other pages. There is also a brief form that can be used to select the type of image you wish to acquire and initiate acquisition of that image. There is a pull-down menu that allows you to select any of the image types the connected camera supports. The "Acquire Image" button will initiate an acquisition of the selected type of image.

The first two links allow you to edit the parameters that are used to control the camera or the server itself. The pages these links lead to are described below.

Setup.htm:

Clicking on the "View/Edit Setup Parameters" link of the main page will direct the browser to the Setup Parameters page. When it is displayed it will appear as follows:

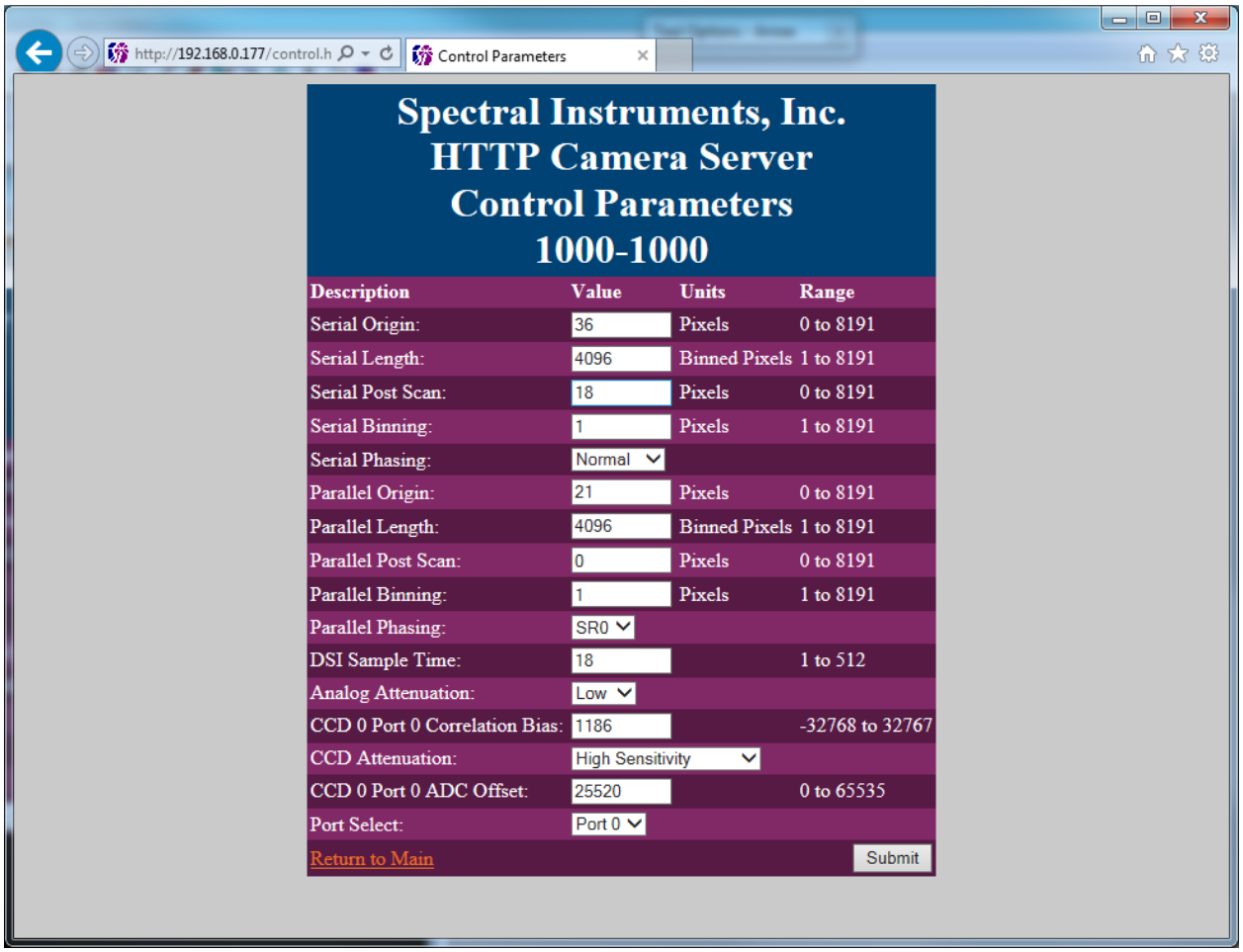


As you can see, many settings for the camera are displayed in editable fields. The "Submit" button on the bottom right corner of the display will submit the form to the CCD Camera HTTP Server and apply the changes you have made. There is a link back to the main page on the lower left corner of the display.

Note that there are parameters here that control server functions as well as camera functions. In particular the "Server Data Source" entry is a server parameter that allows you to select test images from the server's controller or interface board instead of collecting data from the camera. This is provided as a diagnostic feature for debugging possible problems with the system.

Control.htm:

Clicking on the "View/Edit Control Parameters" link of the main page will direct the browser to the Control Parameters page. When it is displayed it will appear as follows:

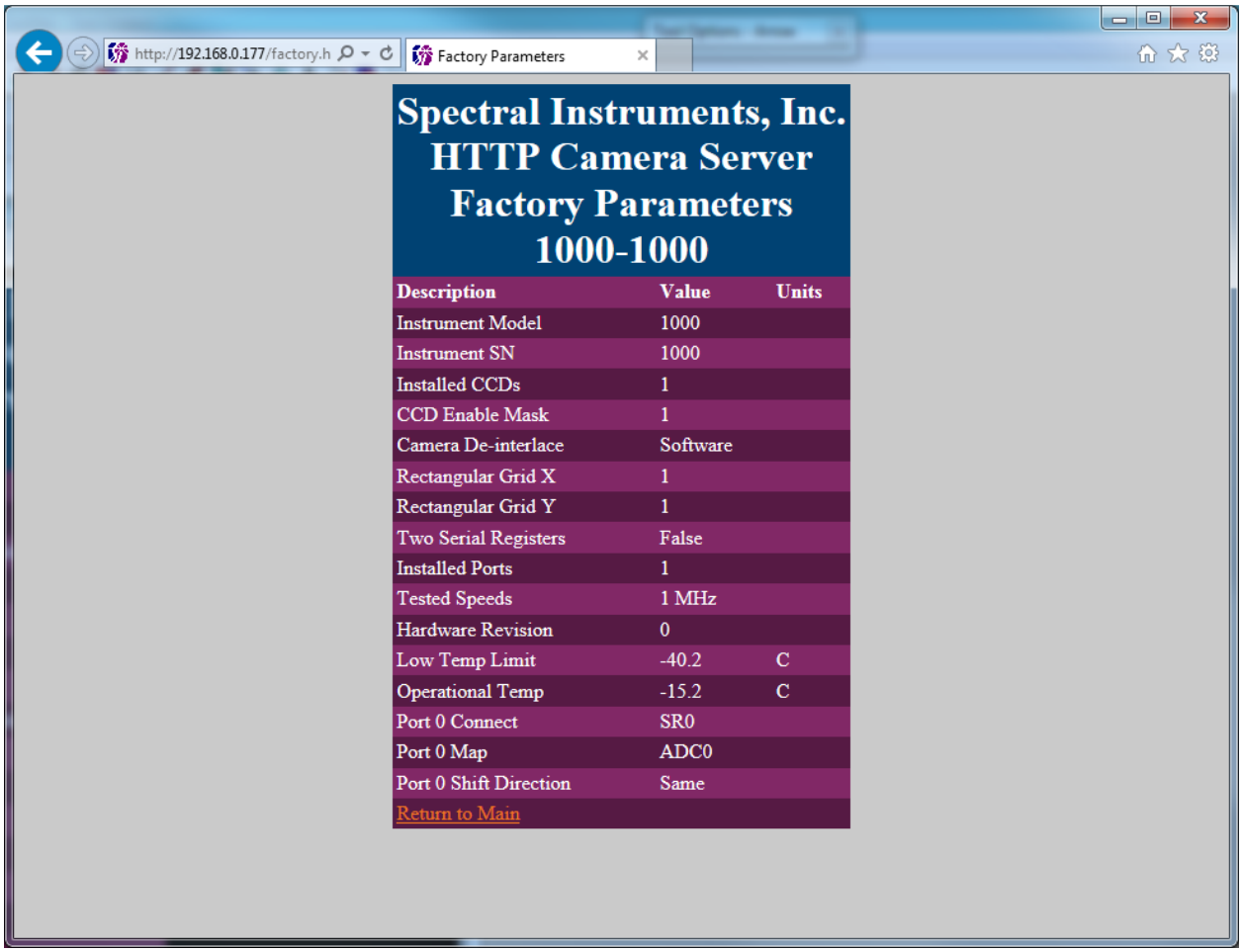


Again, many settings for the camera are displayed in editable fields. The "Submit" button on the bottom right corner of the display will submit the form to the CCD Camera HTTP Server and apply the changes you have made. There is a link back to the main page on the lower left corner of the display.

The parameters on this page directly control the image properties for the next readout.

Factory.htm:

Clicking on the "View Factory Parameters" link of the main page will direct the browser to the Factory Parameters page. When it is displayed it will appear as follows:



Note that this page has no editable fields. This page is for informational purposes only. There is a link back to the main page on the lower left corner of the display.

Status.htm:

Clicking on the "Check Status" link of the main page will direct the browser to the Status Parameters page. When it is displayed it will appear as follows:

Spectral Instruments, Inc.
HTTP Camera Server
Status - 1000-1000

Description	Value	Units
Server Flags:	65	
	1	Camera Connected
	0	Acquisition in Progress
	0	Wait for Trigger
	0	Trigger Received
	0	Server Simulator Data
	0	Interface Simulator Data
	1	Configuration Loaded
	0	Configuration Error
Server Up Time:	463	seconds
Camera Connection Duration:	418	seconds
CCD 0 CCD Temp.:	-272.7	C
Backplate Temperature:	45.5	C
Chamber Humidity:	0	%RH
HKS flags:	4294934548	
	0	TEC Enabled
	0	Back Plate Temp Sensor Override
	1	Back Plate Temp Sensor Present
	0	Back Plate Too Hot
	1	Unnamed bit 4
	1	Alarm Condition
HKS Software Version:	0	
Shutter Status:	Closed	
XIRQA Status:	None	
+3.3 V Supply:	3217	mV
+5 V Supply:	4858	mV
Analog + Rail:	25	mV
Analog - Rail:	-23	mV
+TEC V Supply:	27	mV
+VDD V Supply:	64	mV
Interface Status:	33	
	1	HotLink Signal Detect
	0	HotLink Line Fault Indicator
	0	Data at 100 Mbps
	0	Taxi Signal Detect
	0	Taxi signal good
	1	PLL locked
	0	Frame Valid

Return to Main

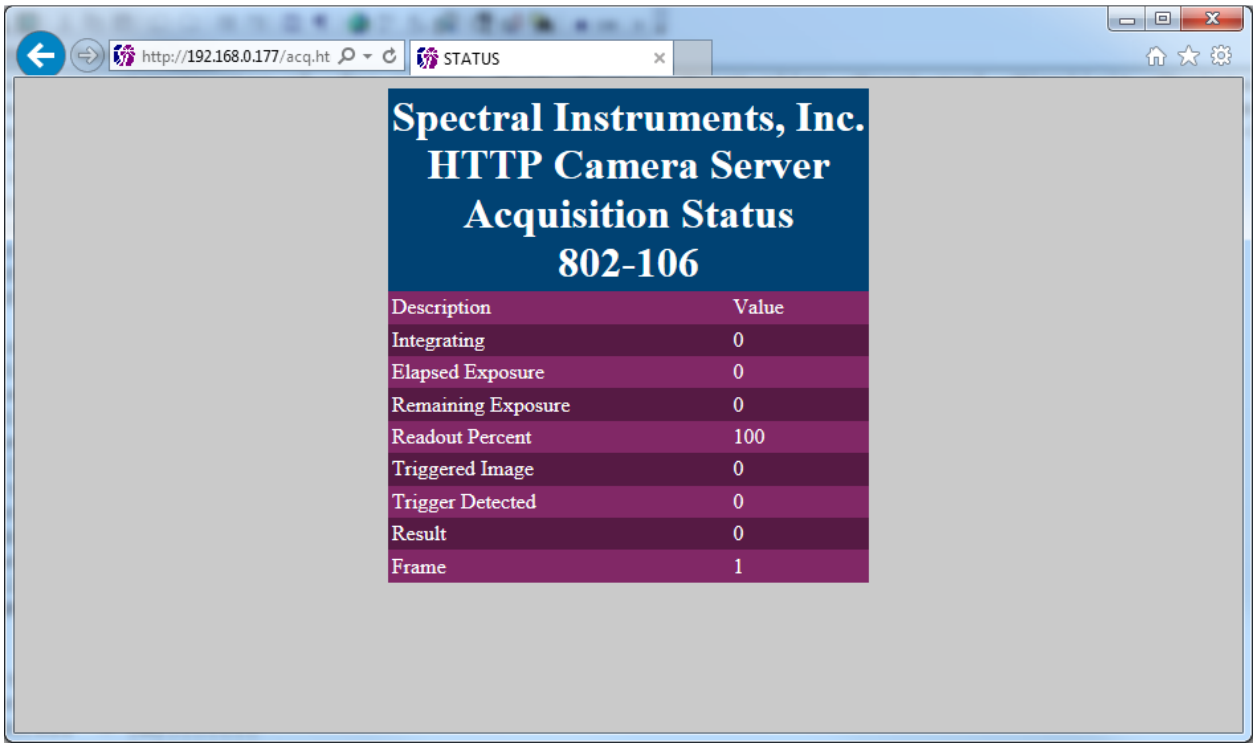
Note that this page has no editable fields. This page is for informational purposes only. Note that bit-field data types have their bits described individually immediately below their value display. There is a link back to the main page on the lower left corner of the display.

This page will request that the web browser automatically refresh it at 3 second intervals. This will allow you to watch the camera cool down to operational temperature, for example.

Acquiring and Saving an Image:

Use the "Image Type" pull-down to select the type of image you would like to collect: "Light" is a normal exposure and "Dark" is an exposure without opening the shutter. There are other types of images that are supported by various cameras.

Once you have selected the type of image, click on the "Acquire Image" button to perform an image capture. The browser will be directed to the acquisition status page. When it is displayed it will appear as follows:

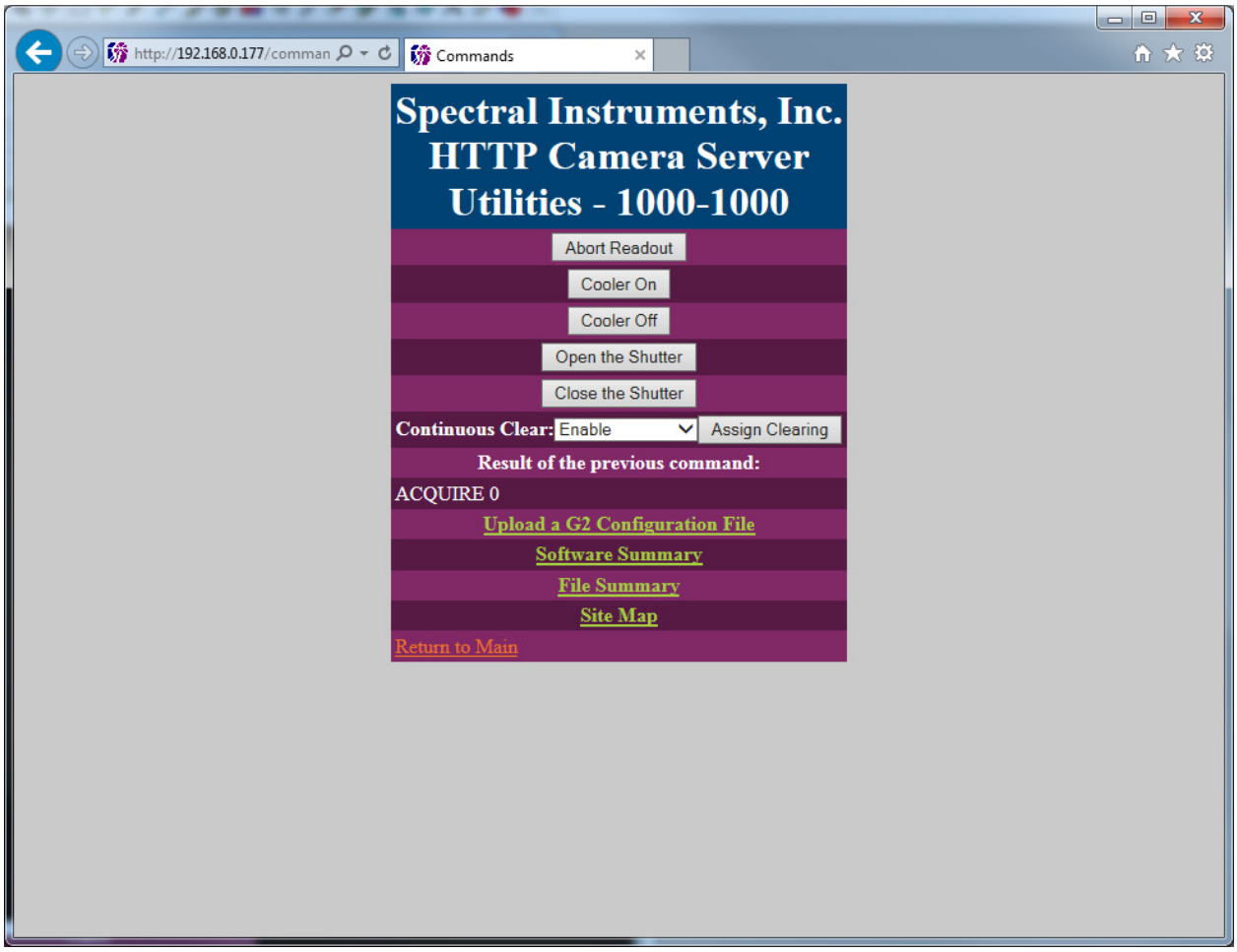


This page will direct your web browser to reload it every second. That will allow you to watch the progress of the exposure and readout. Once the readout has reached 100%, use the "back" button of the browser to go back to the main page.

Clicking on the "Download FITS Image" link of the main page will direct the browser to download the image in the server's image buffer. This will open your browser's file dialog and allow you to save the file. The file will be a 16-bit FITS image with unsigned 16-bit pixels. This is nonstandard and can only be read by some FITS readers.

Command.htm:

Clicking on the "Camera Utilities" link will open the utilities page. When it is displayed it will appear as follows:



There are several buttons that provide control of various features of the camera, such as turning the cooling system on or off. Below the section with buttons, there is a region where the result of the previous command is displayed. This allows you to see any messages the server creates as a command is issued.

Below the message section there are several links to additional pages. The top link directs the web browser to the page that allows you to upload a G2 configuration file. The next three links provide a path to additional information that may be of use. There is a link to return to the main page in the bottom left corner.

Revision History

Revision	Changes
-	Initial release.

The CCD Camera HTTP Server uses the lwIP protocol stack to implement its ICMP, TCP/IP and UDP communications (http://savannah.nongnu.org/projects/lwip/), originally written by Adam Dunkels. The following disclaimer pertains to this protocol stack: