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# AF-1501

## Single Channel, Analog Frame Grabber for CompactRIO


## Features

- Accepts NTSC, PAL and SECAM analog video data (single input).
- Standard 75 ohm BNC connector.
- High-speed 9-bit analog-to-digital converter (ADC)
- Frame rate up to 30 frames/sec[1].
- Ships with LabVIEW FPGA/RT drivers for easy integration with National Instruments cRIO environment.
- QVGA progressive scan mode for motion-sensitive applications.
- Built-in Hardware Accelerated Thresholding: two customizable thresholds can be used independently or together.
- Selectable image inversion
- Programmable Region of Interest (ROI) for arbitrary frame size.
- Industrial Temperature Range (–40 °C to +70 °C)

1 Deployment target dependent: might require the use of one of the special features to achieve this frame rate.

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Rev.: 4 02/19/2010

# Revision History

| REV. | DATE | AUTHOR | DESCRIPTION |
|---|---|---|---|
| 0 | 09/16/2009 | Erik Smeby | Initial Release |
| 1 | 09/29/2009 | Erik Smeby | Added additional figures to "Special Features" section for clarification. |
| 2 | 12/09/2009 | Erik Smeby | Added "Features" section to title page and revision history page. Added "Table of Contents", "Physical Dimensions", and "AF-1501 Block Diagram" sections.<br>Renamed "Feature Compatibility" to "Feature Inter-compatibility" and demoted one level.<br>Added "Electromagnetic Compatibility" and "CE Compliance" items to "Specifications" section.<br>Reformatted and reordered document.<br>Added "Higher clock frequencies may be used, but the driver VI…" in item 16 of the "Getting Started" section. |
| 3 | 02/11/2010 | Erik Smeby | Revised title page photograph.<br>Added Figure 1 to "Physical Dimensions" and renumbered.<br>Revised "Getting Started".<br>Revised "Requirements" section.<br>Replaced "LabVIEW 8.6 or later" with "LabVIEW 2009 or later" in "Software".<br>Replaced "TBD" in Hardware, Target, Memory & Processor with "12 MB min." and "266 MHz min.", respectively.<br>Revised Table 1.<br>Revised Figure 23.<br>Moved Para. "Setup a valid resolution … test patterns are fixed to 640x480." in section "Initializing the AF-1501 module" to section "Configuring the AF-1501".<br>Added "... as well the values for X0 and X1" to "Resolutions in PSS Mode must be divisible…".<br>Renamed section titles in "Advanced API Functions":<br>"Setting the Operational Mode" IS "Configuring the Image Mode"<br>"Changing the Region of Interest" IS "Configuring the Region of Interest"<br>"Changing the Threshold Levels" IS "Configuring the Threshold Levels"<br>"Changing the Test Pattern" IS "Configuring the Test Pattern" |
| 4 | 02/19/2010 | Erik Smeby | Revised "Software" in Introduction.<br>Revised "Safety Information"; added "Disclaimer".<br>Deleted Item 1, "Install the AF-1501 drivers by launching..." from "Getting Started", "Setup and |

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| REV. | DATE | AUTHOR | DESCRIPTION |
|---|---|---|---|
| | | | Installation".<br>Added "Software Installation on the RIO Target" and "Installation of the AF-1501 Driver" to "Getting Started."<br>Added "Understanding the AF-1501 Driver".<br>Added "Integrating the AF-1501 with User Applications".<br>Added "Available Modes of Operation".<br>Revised "Special Features":<br>Added "When to Use …" and "How to Use ..."<br>Added "Test Pattern Generator"<br>Revised "Feature Inter-Compatibility"<br>Updated Table "Special Feature Inter-compatibility Chart"<br>Revised "Specifications":<br>Revised "Active mode (transfer)" from "TBD" to "1 W max.".<br>Deleted "Thermal Dissipation".<br>Revised "Application Programming Interface" and "Advanced API"<br>Removed redundant descriptions of "error in" and "error out".<br>Removed redundant descriptions of "Configuration (Read)", "Mode (Read)", "ROI (Read)", etc. |

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# Table of Contents

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## Introduction

The AF-1501 captures analog video on the CompactRIO platform. The digitized data is transferred across the CompactRIO backplane to the real-time processor through a direct memory access (DMA) channel. The real-time processor then converts the image to a format that can easily used with IMAQ for easy integration with National Instruments' machine vision libraries. There are a number of built-in features into the AF-1501 that reduce the amount of processing required for common image processing functions.

## Minimum Requirements:

Software
- Host Computer
  - LabVIEW .....2009 or later
  - LabVIEW Real-Time.....9.0.0 or later
  - LabVIEW FPGA.....9.0.0 or later
  - LabVIEW Vision.....9.0.0 or later
  - AF-1501 Driver.....1.x.x
- Target
  - LabVIEW Real-Time.....9.0.0 or later
  - NI RIO.....3.2.x or later
  - NI VISA .....4.6.x or later
  - NI VISA Server .....4.6.x or later
  - NI Vision RT .....9.0.0 or later

Hardware
- Target.....Single-Board RIO or Compact RIO
  - Memory.....12 MB min.
  - Processor.....266 MHz min.
  - Slot.....1 available

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## Physical Dimensions

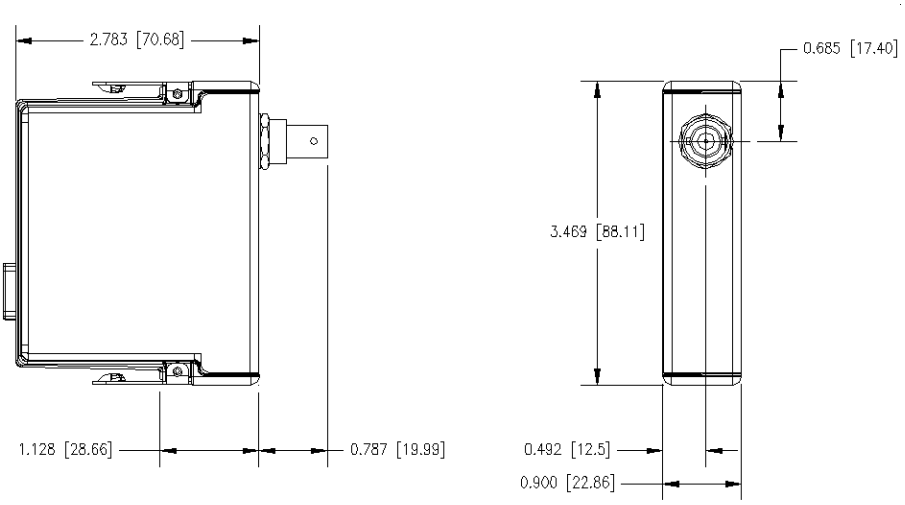


Figure 1: Physical Dimensions for the AF-1501

## Safety Information

## Disclaimer

Operate the AF-1501 only as described in these operating instructions. The safety guidelines and specifications in this document are specific to the AF-1501. Any other components in the system might not meet the same safety ratings and specifications. Refer to the documentation for each component in the system to determine the safety ratings and specifications for the entire system.

MoviMED's AF-1501 is not authorized for use as critical component in life support devices or systems without the express written approval of MoviMED.

Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.

A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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## AF-1501 Block Diagram

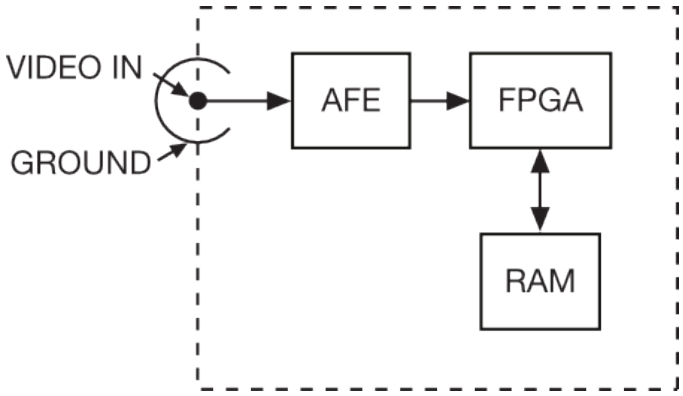


Figure 2: Functional Diagram of the AF-1501

The incoming analog video signal is digitized by the analog video front end (AFE) and buffered by the on-board FPGA . The image is temporarily stored and de-interlaced by on-board random access memory (RAM). The on-board FPGA transfers images to the RIO back plane FPGA upon request. Refer to Figure 2 for system diagram of the AF-1501 module.

## Connecting the AF-1501

Connect a composite video source to the BNC on front panel on the module. Plug the module into an available slot on the CompactRIO chassis. No external power supply is required.

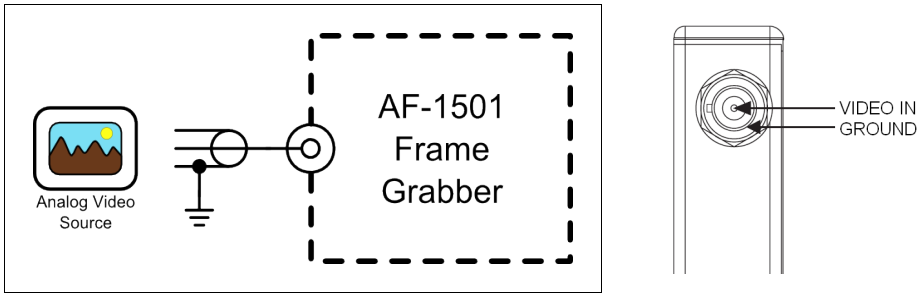


Figure 3: Connecting a Video Source to the AF-1501

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# Getting Started

## Software Installation on the RIO Target

To install the proper software on CompactRIO or Single-Board RIO hardware, you must first install it on the host PC. The only necessary components listed under *Minimum Requirements, Software* in *Introduction* section. The software components installed the PC can be verified in **Measurement & Automation Explorer (MAX)** by expanding the software tab under **My System**. Once it has been verified that the host PC has the correct software, it needs to installed on the CompactRIO controller to meet the minimum requirements for transferring an image from the RT target.

Before you powering up the CompactRIO or Single-Board RIO hardware, install the AF-1501 frame grabber module into Slot 1. Once the module has been plugged in, proceed to power the system up and connect it to the local network via the Ethernet port on the controller.

The CompactRIO controller should appear in MAX under the Remote Systems tab. Expand the target , right-click on **Software,** and select **Add/Remove Software**. This opens the LabVIEW Real-Time Software Wizard. Select **Custom software installation** and click **Next**. Select **Yes** to continue with the manual installation. The three required pieces of software are NI NI Vision 9.0, LabVIEW Real Time 9.0 and NI RIO 3.2.x. Install any required dependencies of the mentioned three components. Once you have selected all of these to install, click Next to begin the installation (See Figure 4).


Figure 4: Installation of Required Components on the RIO Target

When you have finished installing the required software and the system has rebooted, the RIO system has the required systems components for interfacing with the AF-1501 driver.

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## Installation of the AF-1501 Driver

In order to operate the AF-1501, the user needs to download the driver from http://www.movimed.com. Once the driver installer is saved to disk, double click on it. The installer will prompt the user to select where to install the necessary files. The user will have the option to install other options such as documentation and examples. If the user is satisfied with the default settings for file locations, click **Next** until you reach the last window and click **Install**.

## Setup and Installation

1. Install the AF-1501 into an available slot on the RIO Target while the power is off.
2. Power on the RIO Target.
3. Open LabVIEW and select from the **File » New Project** to create an empty project.
4. Right-click the **Project** icon in **Project Explorer** and select **New » Targets and Devices…** (See figure below).

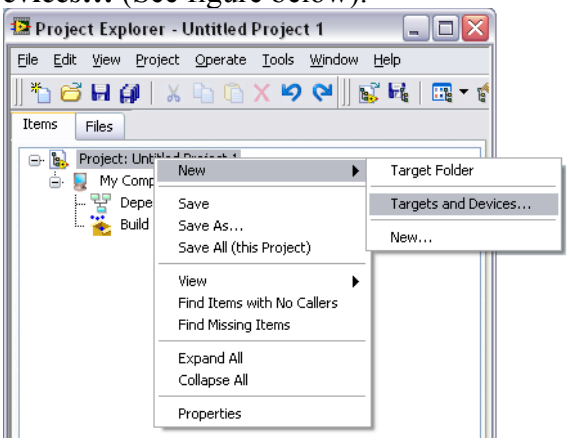


Figure 5: Adding a New RIO Target to the Project

5. In the **Targets and Devices** section of the **Add Targets and Devices** windows, select a target from either the Real-Time CompactRIO or Real-Time Single-Board RIO and click **OK**.
6. In the **Select Programming Mode** dialog box, select **LabVIEW FPGA Interface** and click **Continue**.
7. If the LabVIEW prompts to discover C Series modules, click **Discover**.
8. If the **AF-1501** module appears the the **FPGA Target** tree (as "Slot 1, AF-1501", for example), skip to step 13.
9. If the module was not automatically detected, right-click the FPGA Target tree and select **New » C Series Modules …** .

10. With the **"Existing target or device"** option selected, expand the **C Series Module** tree to try automatically detecting the module.
11. If the module was not detected in step 10., then select **"New or target device"** and then select **"C Series Module"** under **Targets and Devices**. Click **OK** to continue.
12. In the **"New C Series Module"** dialog box under **Module Type**, select **AF-1501** from the drop-down menu. Select the Slot the module is connected in. If the module is not in the list, the driver is not correctly installed. Click **OK**.
13. The module will show up in the **FPGA Target** tree. If not, check that the driver is properly installed and the module is correctly installed in the chassis slot. If steps 11. through 12. were followed, the module should appear in **Project Explorer** if the driver is installed properly. (See figure below)

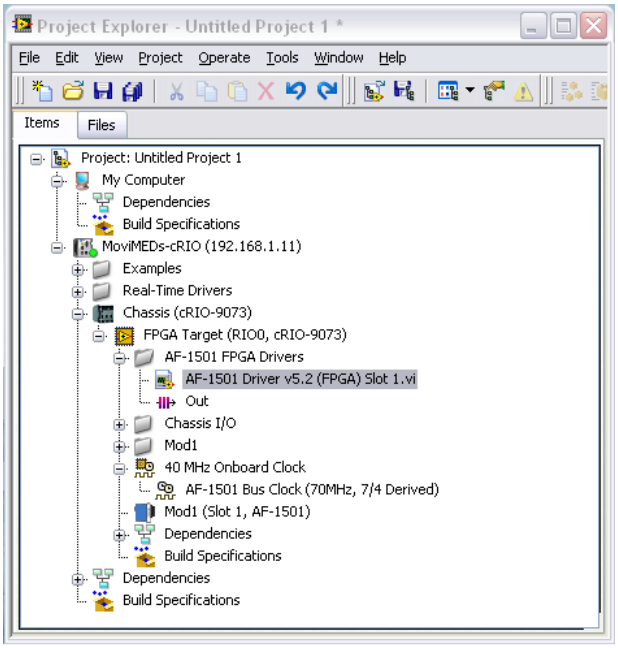


Figure 6: A Project Setup for the AF-1501

14. Open the example from the **NI Example Finder** under **Toolkits and Modules » FPGA » CompactRIO » Module Specific » Analog Input » MoviMED » AF-1501 » AF-1501 Examples.lvproj**. Copy (drag while holding the ***control*** key) the **"AF-1501 FPGA Drivers"** folder from the example project under the **FPGA Target** tree into the **FPGA Target** tree in your project. This folder contains an **"Out"** FPGA FIFO and the **"AF-1501 FPGA Driver vX.Y … .vi"** main FPGA driver VI file.
15. Copy the derived clock (expand the the base clock tree) from the example project or create a FPGA Derived Clock named **"AF-1501 Bus Clock"** at **70 MHz, or higher**, *if the target permits*. Verify the clock is at this frequency exists and no error exists in the project with the clock. It will be necessary to edit the clock

properties if any modifications have been made to it. Higher clock frequencies may be used, but the driver VI may not compile on some targets.

16. Install the real-time drivers into your project by copying the folder named **"Real-Time Drivers"** and **"Examples"** from the example project under the **RIO Target** tree in your project under the **RIO Target** tree.
17. Open the low-level driver folder as created in step 16. Right-click the FPGA driver VI for the slot the module is installed in and select **Compile**, if not done already. The real-time driver will not run without a compiled copy of the low-level driver.
18. Open the "**AF-1501 Open.vi**" real-time driver and check to make sure it is not broken (broken, gray run icon). If it is broken, the driver may not be installed properly or compiled.
19. Connect a video source to the AF-1501.
20. Copy Example 1 from the NI Example Finder (**Help » Find Examples...**) under **Toolkits and Modules » FPGA » CompactRIO » Module Specific » Analog Input » MoviMED » AF-1501 » AF1501 Examples.lvproj**. The VI(s) should be copied to the project created in the previous section.
21. Run Example 1 and, optionally, Example 2 with the default settings. The Configuration control on the front panel of either VI allows the user to test different settings on the AF-1501.
22. Switch to the block diagram to display the code used to communicate with the AF-1501.

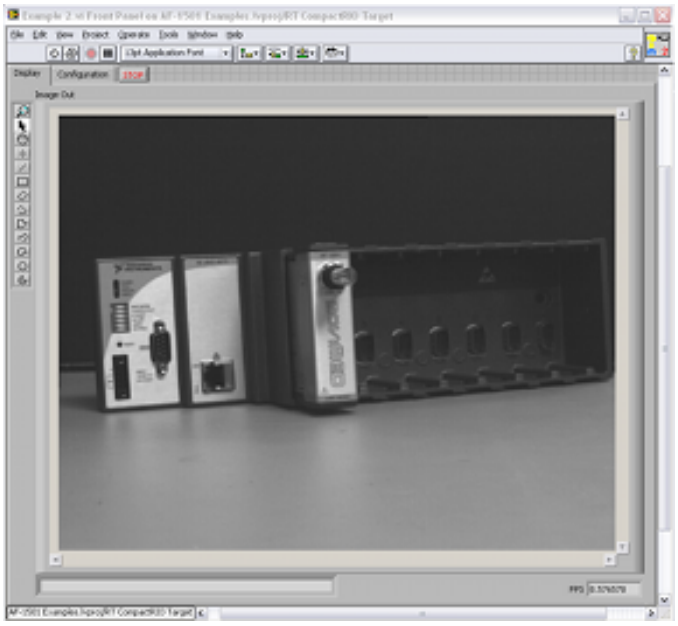

Figure 7: Front Panel of Example 2 after Grabbing an Image

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# Programming the AF-1501

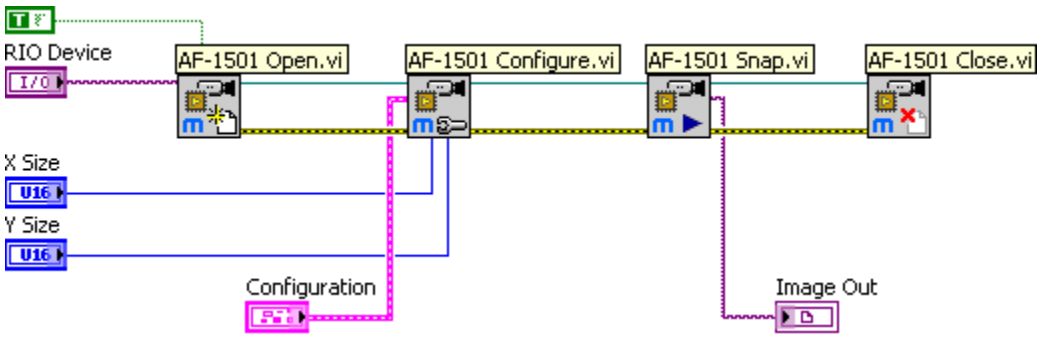


Figure 8: Example Program to Grab an Image from the AF-1501

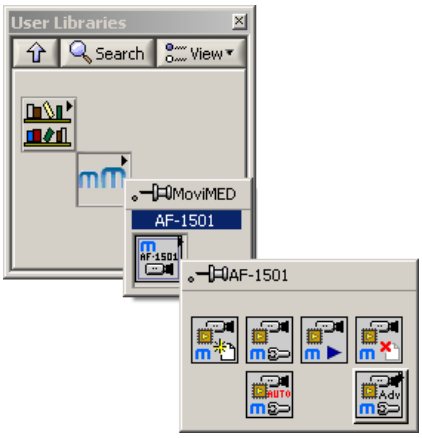


Figure 9: Location of AF-1501 Drivers in Functions Palette

## *Initializing the AF-1501 module*

When creating your own LabVIEW code to access the AF-1501, the module first must be initialized with the "**AF-1501 Open.vi**" function[2]. Remaining VI functions need to have session and error terminals cascaded to each other. Wire either a constant or control to the **RIO Target** input and the **Slot** input. The RIO Target was setup in the section entitled, Setup and Installation, Step 5.

2 LabVIEW must be restarted before the drivers will appear in the functions palette.

## *Configuring the AF-1501*

When configuring the AF-1501, the "AF-1501 Configure.vi" function must be called. The configuration functions sets or gets the Bit Mode, Image Invert, Threshold, Region of Interest (ROI), and Progressive Skip Sampling (PSS).

Bit Mode selects from 8-bit, 4-bit, 1-bit (threshold), or a test pattern (8-bit). The invert option allows the output image to be inverted bit-wise. This feature is useful in combination with thresholding. However, the output is not affected by the invert setting when a test pattern is selected. When using PSS Mode, the output resolution is reduced by half. The frame rate will be higher as a result.

Threshold mode is activated by setting the Bit Mode to 1-bit, and setting either the low or high threshold comparison enable to TRUE. A threshold value must be set. When neither of the threshold comparators are enabled, the output will be black.

Setup a valid resolution with the **X Size** and **Y Size** inputs. The default resolution is **`640x480`**. Resolutions in ROI Mode must be divisible by two (2), and resolutions using thresholding must be divisible by six (6), as well the values for X0 and X1. The resolution for the test patterns are fixed to **`640x480`**.

⚠ *Note: Specifying an invalid resolution will result in errors or unpredictable behavior. See Table 1 for a list of valid settings.*

## *Grabbing an Image from the AF-1501*

Call the "**AF-1501 Snap.vi**" to grab an image. The output data format is IMAQ. The output then can be wired to additional IMAQ or machine vision functions for processing or display.

## *Closing communication with the AF-1501*

Call the "**AF-1501 Close.vi**" when the loop ends to shutdown the driver at end of your program. Not following this step will lead to errors and unpredictable results.

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## Example 3: Barcode Reader

Implement the following code in LabVIEW:

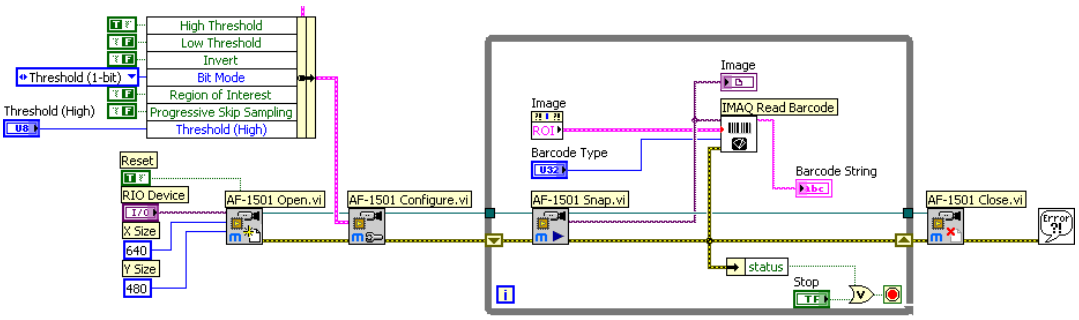


Figure 10: Barcode Reader Example Code

1. Add the basic AF-1501 functions from the **User Libraries » MoviMED » AF-1501** palette. Create the controls and indicators shown in Figure 10.
2. For configuration, create a constant from the input terminal. Then, either set the values directly in the constant, or wire the constant into a **Bundle by Name** function for clarity.

   ⚠ *Note: Settings not shown in Figure 10 will not affect this example and can be set to their default values.*

   ⚠ *Note: For a faster response time, use* **`320x240`** *with PSS enabled instead of* **`640x480`**.
3. Use the "**IMAQ Read Barcode**" function from the **Vision and Motion » Machine Vision » Instrument Readers** function palette.

   ⚠ *Note: The "IMAQ Read Barcode" function will work with grayscale but at a much slower speed.*
4. Place an **Image Display** (IMAQ) indicator on the front panel from the from the **Vision** control palette. Right-click the indicator and select the **Palette » Binary** option.
5. Right-click the IMAQ indicator on the block diagram and select **Create » Property Node » ROI**.
6. Set the **Barcode Type** to ***Code 128*** on the front panel. You may experiment with detecting the other barcode types as well.
7. Set the threshold (high) to a value between 50 and 120, depending on the image quality and brightness. It might be necessary to display the image in grayscale mode first to find a good value for the threshold.

⚠ *Note: The camera should be in focus for this exercise.*

8. Press the **Run** button to start the VI. You may change the barcode type during execution.
9. Aim the camera at one the following barcodes to scan and detect the secret message(s):

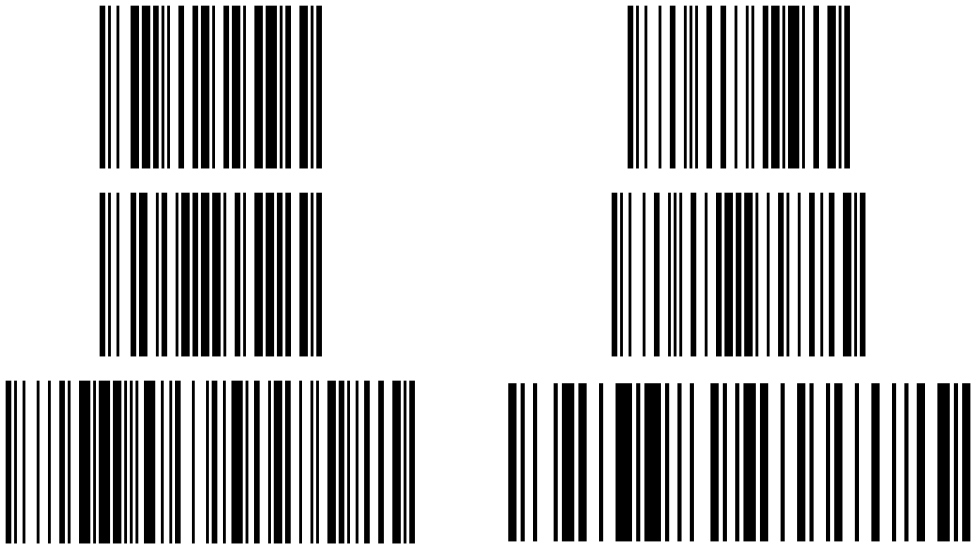

Figure 11: Sample Barcodes (Code 128)

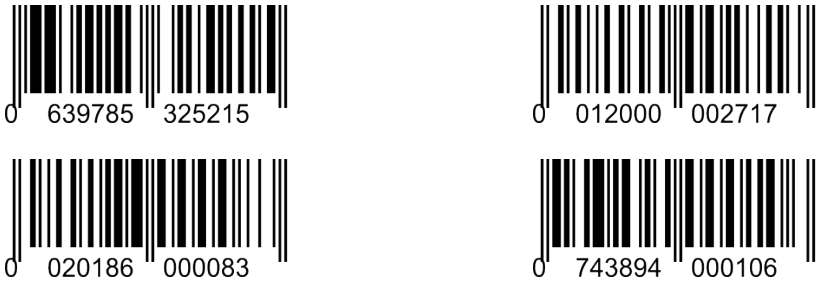


Figure 12: Sample Barcodes (UPC-A)

10. Press the **Stop** control you created when finished or need to adjust the threshold value.

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# Understanding the AF-1501 Driver

Understanding the AF-1501 driver for LabVIEW is crucial for users using this C-series module in their applications. It is recommended to complete the "Getting Started" section prior to reading this section, as it will further help to understand the AF-1501 driver.

The AF-1501 driver has three main components:

- The AF-1501 FPGA Driver
- The AF-1501 DMA Channel (FIFO)
- The AF-1501 Real Time Driver

Figure 13 shows how the different components of the AF-1501 map into the actual LabVIEW project. In Figure 13, we can see from bottom to top the following blocks:

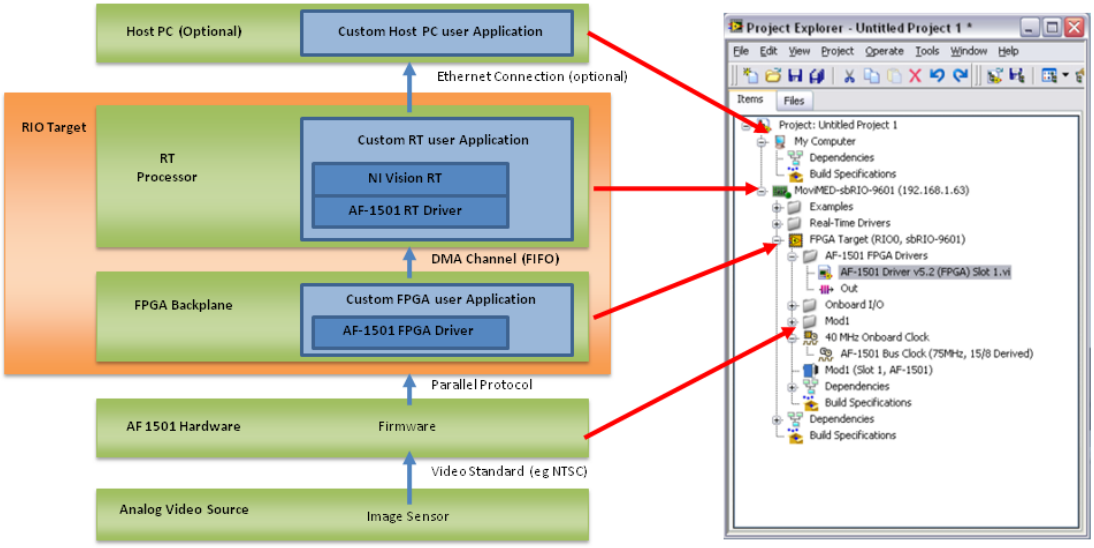


Figure 13: AF-1501 Communication Layers

- **Analog Video Source**: Grabs the image and sends it to the frame grabber using a particular video standard (NTSC/PAL/SECAM).
- **AF-1501 Module**: Performs de-interlacing, buffers the image, and sends it to the RIO FPGA backplane.
- **FPGA Backplane (on RIO Target)**: Receives the image from the module and sends it up to the RT processor via a DMA channel (FIFO).
- **RT Processor (on RIO Target)**: receives the image from the DMA channel and processes it.
- **Host PC (optional)**: Allows the user to program, monitor and debug the application.

⚠ *Note: LabVIEW projects are organized with a hierarchical structure. This structure locates the FPGA Target under the RT Target tree. The C-Series Module is under the FPGA Target tree. This structure should not be confused with the block diagram described previously.*

⚠ *Note: The presence of the analog video source is transparent to LabVIEW. If no source is connected, a black image will be captured.*

The three levels the user can interface with in their applications are the FPGA Backplane, the RT Processor, and the optional Host PC. The following subsections will describe how to program in those three levels using LabVIEW as well as a brief description of the driver.

## The AF-1501 FPGA driver

The driver has the following characteristics and requirements:

- Performs the low-level communication with the AF-1501 module.
- Transfers the data to the RT processor through a DMA channel (FIFO).
- Clock speed dependent
- Requires compilation

⚠ *Note: The compilation frequency of the AF-1501 FPGA driver is target and custom user FPGA code dependent. This compilation frequency might affect the performance of the application. See Compiling the FPGA Driver VI Code section for details.*

⚠ *Note: To locate the AF-1501 FPGA driver go to your project and under Help » Find Examples you will open the NI Example Finder. Type AF-1501 in the search field. Open the "AF-1501 Examples" project. The AF-1501 FPGA driver can be found under* ***RT CompactRIO Target » Local Chassis » FPGA Target » AF-1501 Drivers » AF-1501 Driver vX.X*** .

## The AF-1501 DMA Channel (FIFO)

This element allows the transaction of image information from the FPGA level to the RT level. The AF-1501 channel uses one (1) of the three (3) DMA channels available on the RIO target. The DMA channel is called "**Out**" and resides in the example project. Only a single instance of the DMA channel is allowed at the FPGA level. As the AF-1501 FPGA

driver already has that instance the user is not allowed to invoke that Channel at the FPGA level any more.

> ⚠ *Note: To locate the AF-1501 DMA Channel, go to Help » Find Examples and open the NI Example Finder. Type AF-1501 in the search field. Open the "AF-1501 Examples" project. The AF-1501 DMA Channel can be found under* ***RT CompactRIO Target » Local Chassis » FPGA Target » AF-1501 Drivers » Out****.*

## The AF-1501 Real-Time Driver

The AF-1501 Real-time driver has the following characteristics:

- Assembles the image on the RT process with two possible image output formats: IMAQ image (for with IMAQ compatible image processing and machine vision functions) and 2D image array.
- Fully integrated with LabVIEW as a add-on functions palette after the driver installation. The driver API is located under **User Libraries » MoviMED » AF-1501** as shown in Figure 14.

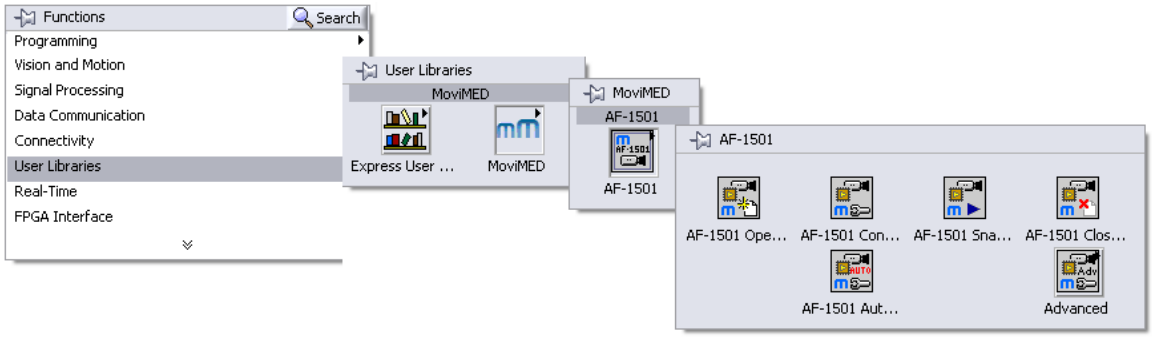


Figure 14: Location of the AF-1501 API in the Functions Palette

Programming an application that involves image acquisition with the AF-1501 always requires the following VIs: Open, Configure, Grab Image, Close. This follows the typical IMAQ paradigm. Refer to the AF-1501 API or the online help for more details how to use the Advanced functions.

# Integrating the AF-1501 with User Applications

## FPGA vs. Scan Mode

The AF-1501 is only supported under FPGA mode because it has a driver at the FPGA level. If the user application requires the use of Scan Mode (Scan Engine) there are two alternatives:

- Use Hybrid (Mixed) Mode : follow the instructions on the document "Using Scan Engine and FPGA Simultaneously on a CompactRIO", Document ID: 4XRBMIUV from National Instruments website.
- Write a simple FPGA piece of code to poll values from the FPGA level to the RT level using the front panel interface. See *Adding Custom FPGA code* for more details.

⚠ *Warning: MoviMED does not recommend the use of Hybrid Mode. Scan Mode requires two additional DMA channels. Using Hybrid Mode will use all of the three available DMA channels (2 for the Scan Engine and 1 for the AF-1501).*

## Adding Custom FPGA code

If the user application does not need custom FPGA code, skip this section and go to *Compiling the FPGA Driver VI Code*. If the user application requires custom FPGA code, ***add*** custom FPGA code to the FPGA driver VI without modifying the existing code on the block diagram. Locate the AF-1501 FPGA driver (see *The AF-1501 FPGA driver* for more details) and add any custom user code outside the single cycle loop used for the FPGA driver. Do not change any signals going in or out from the single cycle loop. The user can create controls and indicators as needed, use different clock rates and create any programming item as long as its execution does not interfere with the AF-1501 FPGA driver.

The user FPGA code functionality can be accessed from driver front panel by using a R/W Control VI's from the FPGA Interface palette. See Figure 15 as a simple example of writing a custom signal at the FPGA level and reading a custom value from the FPGA level together with imaging functions. Find also the location of the FPGA VI's depicted in the same figure.

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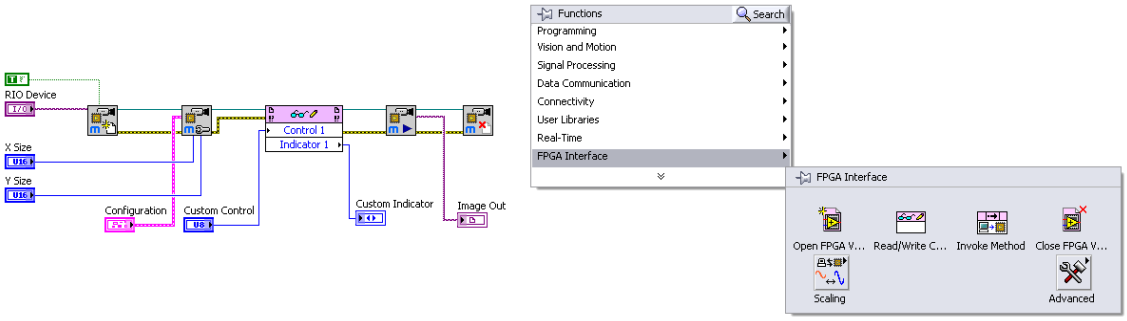


Figure 15: Accessing User Code Embedded in the AF-1501 Driver

⚠ *Warning: Any change to the name of the FPGA driver will require the user to relink that FPGA VI on the open reference located in the Open Session VI of the AF-1501 RT driver and the "AF-1501 Session.ctl".*

## Compiling the FPGA Driver VI Code

Once your FPGA code is ready (with or without custom FPGA code) you will need to compile the FPGA code. In order to do that go to the Project and under FPGA target find the FPGA driver VI. Right-click the VI and select Compile. Compilation typically takes 8 to 13 minutes for the AF-1501 FPGA driver alone. Custom FPGA code could extend compilation times.

⚠ *Note: Compilation clock rates vary among backplanes. The default compilation frequency is 80 MHz. Depending on the FPGA code, the achievable compile frequency might vary. If the compiler, returns an error about the compilation frequency, the user should use a frequency below the maximum allowed frequency displayed by the FPGA error during compilation.*

## Creating a Real-Time application

See *The AF-1501 Real-Time Driver* to program Real-Time vision applications using information coming from the AF-1501. The user can find the AF-1501 API functions in the **User Libraries » MoviMED » AF-1501**. First,a session needs to be opened to the AF-1501. Next, the driver needs to configure the module. Third, the "Snap" function is called to grab an image. When using IMAQ output format of the driver, the user can pass image into the NI Vision functions set for seamless integration with National Instruments' machine vision and image processing libraries. After finished grabbing images, the session needs to be closed.

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## Creating a Host PC application

Host PC applications can take advantage of the National Instruments' built-in data transferring mechanism from the RT target for development purposes. This means that any code running on the RT target accessing the AF-1501 can be moved to the host PC. In order to code a host PC application using the AF-1501, the user should follow exactly the same procedure as if they were coding an application on the RT target, except the VI should be moved to "My Computer" in the project. Also, the RIO I/O control or constant is required to be updated from a local to remote resource name.

External resources, such as databases or other storage devices not available on the RT target, might require the coding of a Host PC application.

> ⚠ *Note: Since the application runs at the host PC, the some of the processing happens at the local PC and not on the target. Therefore, the performance and timing is not representative of compared to the results if the whole applications was run completely on the target.*

## Using the AF-1501 in a Different Slot than the Default

The "Getting Started" guide details how to setup a project, compile and run the code so that the user can grab an image with an AF-1501 located in Slot 1. This section will discuss how to configure the AF-1501 to work in another slot. In order to work with the AF-1501 in a different slot the user will need to modify the AF-1501 FPGA driver I/O nodes:

1. Locate the AF-1501 FPGA driver in your project.
2. *Optional*: Save it as a local file in your work folder and call it "AF-1501 FPGA Driver vX.X Slot Y", where vX.X is the version of the FPGA driver and Y is the installed slot. This will help avoid confusion which slot the driver is compiled for.
3. Add the saved file to your project in **FPGA Drivers** folder under **FPGA Target** Tree.
4. Add the module I/O nodes to your project for the slot it is installed in (See *Figure 16*). To do this, select **Add C Series modules …** from the **FPGA Target** tree in your project. Select **New target or device** and select **AF-1501** for the **Module Type**. Select the desired slot number from the **Location** pull-down menu.

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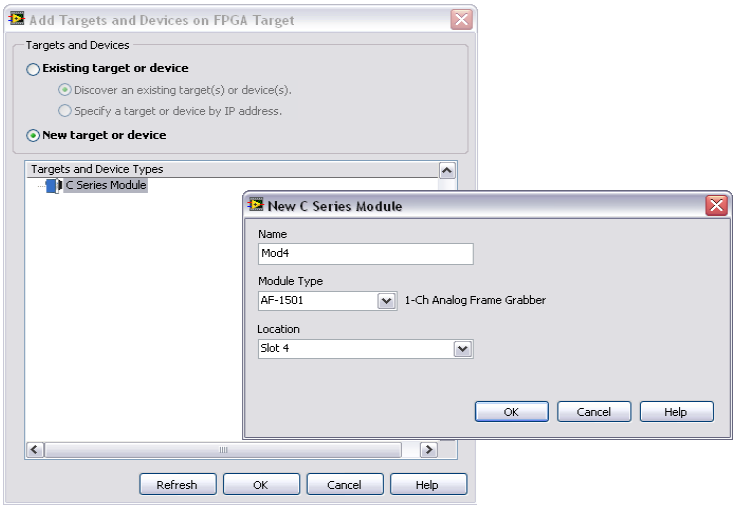


Figure 16: Adding New Module I/O Nodes to the Project

5. Open the FPGA driver VI block diagram.
6. Modify the following FPGA I/O nodes with the new I/O line values. Below is a list of I/O values that need to be changed, where Y is the slot to use the AF-1501 in, for example if using slot 7, then Y=7:

   (1) "Mod1/SPI Conv(DIO3)" → "ModY/SPI Conv(DIO3)"
   (2) "Mod1/Trigger(DIO1)" → "ModY/Trigger(DIO1)"
   (3) "Mod1/SPI MISO (DIO6)" → "ModY/SPI MISO (DIO6)"
   (4) "Mod1/OvrSmpClk(DIO0)" → "ModY/OvrSmpClk(DIO0)"
   (5) "Mod1/SPI RdyBsy(DIO2)" → "ModY/SPI RdyBsy(DIO2)"
   (6) "Mod1/SPI Clk" → "ModY/SPI Clk"
   (7) "Mod1/ID Select" → "ModY/ID Select"
   (8) "Mod1/SPI CS(DIO5)" → "ModY/SPI CS(DIO5)"
   (9) "Mod1/SPI Func(DIO4)" → "ModY/SPI Func(DIO4)"

7. Save your VI
8. Compile the VI
9. If the FPGA Driver was renamed, open the"AF-1501 Open" VI from the AF-1501 palette. Otherwise, skip to the next step. Locate the "Open FPGA reference" node and relink it to the new driver file by right-clicking the node and selecting "Configure Open FPGA reference". Select the new VI by clicking the folder path icon.

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# Available Modes of Operation

## Default Configuration

Typically, the user will pick default values as a first choice. The default values give the maximum resolution (640x480) and the maximum bit depth (8-bits). If the performance is good enough for the user's application, then the default values should suffice. However, if the user's application requires more performance then the user can take advantage of one or more of the special features. See section *Special Features* for more details.

The default values when nothing is wired to the configuration VI are as followed:

| | |
|---|---|
| X-Size: | 640 |
| Y-Size: | 480 |
| Bit-Mode: | 8-Bit |
| Invert: | Disabled |
| PSS: | Disabled |
| ROI: | Disabled |

## How to Set the Configuration

The configuration is set by right-clicking the **Config (Write)** input of either the "**AF-1501 Configure.vi**" or "**AF-1501 Configure Mode.vi**" functions in the **User Libraries » MoviMED » AF-1501 Palette** in LabVIEW and selecting "Create Constant" or "Create Control" from the drop-down menu. The values can be changed by either modifying them in the constant directly (See Figure 17) or inserting a "Bundle by Name" in between them (See Figure 18) and creating constants in a similar fashion to the inputs.

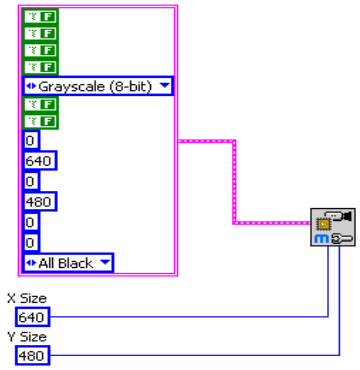


Figure 17: Configure using a Constant

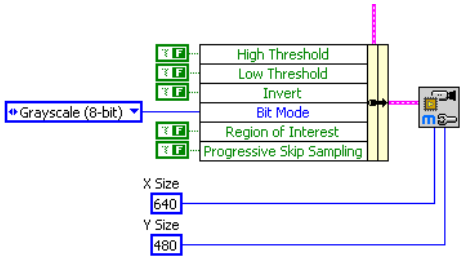


Figure 18: Configure using Bundle

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## Valid Settings

InTable 1, configuration parameters for valid modes are listed. See section *How to Set the Configuration* for more information on configuring the module. Set the image size with **X Size** and **Y Size**. See sections *Progressive Skip Sampling* and *Programmable Region of Interest* for more details on how to use the ROI and PSS modes.

| Mode | TL | TH | X | Y | Bit Mode | ROI | PSS | Comments |
|---|---|---|---|---|---|---|---|---|
| 640x480x8 bits | N/A | N/A | 640 | 480 | 8-Bit | F | F | Default |
| 640x480x4 bits | N/A | N/A | 640 | 480 | 4-Bit | F | F | SOM |
| 636x480x1 bit | T or F or T | F or T or T | 636 | 480 | 1-Bit | F | F | Threshold |
| 320x240x8 bits | N/A | N/A | 320 | 240 | 8-Bit | F | T | PSS |
| 320x240x4 bits | N/A | N/A | 320 | 240 | 4-Bit | F | T | PSS, SOM |
| 318x240x1 bit | T or F or T | F or T or T | 318 | 240 | 1-Bit | F | T | PSS, Threshold |
| ROI, 8 bits | N/A | N/A | X1-X0 | Y1-Y0 | 8-Bit | T | F | X1>X0, Y1>Y0,<br>X0 = 0 – 639, X1 = 1 – 640,<br>Y0 = 0 – 479, Y1 = 1 – 480. |
| ROI, 4 bits | N/A | N/A | X1-X0 | Y1-Y0 | 4-Bit | T | F | X1>X0, Y1>Y0,<br>X0 = 0, 2, 4, … 638,<br>X1 = 2, 4, 6, … 640,<br>Y0 = 0 – 479, Y1 = 1 – 480. |
| ROI, 1 bit | T or F or T | F or T or T | X1-X0 | Y1-Y0 | 1-Bit | T | F | X1>X0, Y1>Y0<br>X0 = 0, 6, 12, … 630,<br>X1 = 6, 12, 18, … 636,<br>Y0 = 0 – 479, Y1 = 1 – 480. |
| ROI, PSS, 8 bits | N/A | N/A | X1-X0 | Y1-Y0 | 8-Bit | T | T | X1>X0, Y1>Y0,<br>X0 = 0 – 319, X1 = 1 – 320,<br>Y0 = 0 – 239, Y1 = 1 – 240. |
| ROI, PSS, 4 bits | N/A | N/A | X1-X0 | Y1-Y0 | 4-Bit | T | T | X1>X0, Y1>Y0,<br>X0 = 0, 2, 4, … 318,<br>X1 = 2, 4, 6, … 320,<br>Y0 = 0 – 239, Y1 = 1 – 240. |

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| Mode | TL | TH | X | Y | Bit Mode | ROI | PSS | Comments |
|---|---|---|---|---|---|---|---|---|
| ROI, PSS, 1 bit | T or F or T | F or T or T | X1-X0 | Y1-Y0 | 1-Bit | T | T | X1>X0, Y1>Y0<br>X0 = 0, 6, 12, … 312,<br>X1 = 6, 12, 18, … 318,<br>Y0 = 0 – 239, Y1 = 1 – 240. |
| Test Pattern | N/A | N/A | 640 | 480 | Test Pattern | F | F | |

Table 1: Valid Configuration Settings for Various Modes

## Special Features

The AF-1501 analog frame grabber allows the user to take advantage of a set of special built-in features. These features give the user flexibility to work with different image sizes and bit depths, use common image processing tools or have tools to verify the status of the system. All special features are implemented at the hardware level in the AF-1501.

**Summary of Special Features:**

- Progressive Skip Sampling
- Programmable Region of Interest
- Speed Optimized Mode
- Image Inversion
- Hardware Accelerated Thresholding
- Test Pattern Generator

## Progressive Skip Sampling

The Progressive Skip Sampling mode (PSS mode) allows the AF-1501 user to increase the frame rate by decreasing the resolution. In this mode the AF-1501 will sample every other pixel in both horizontal and vertical directions.

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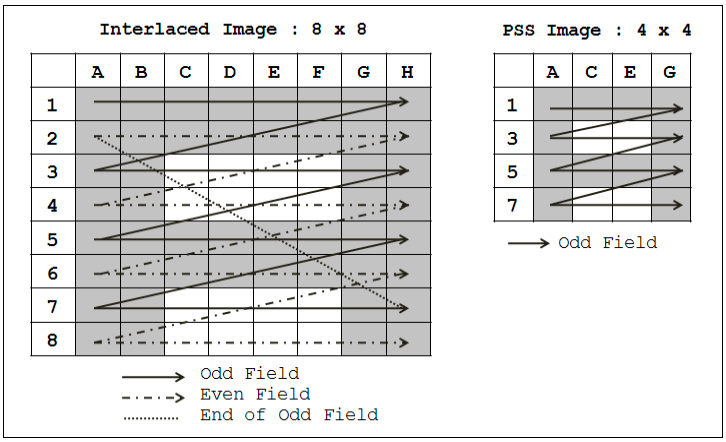


Figure 19: Progressive Skip Sampling

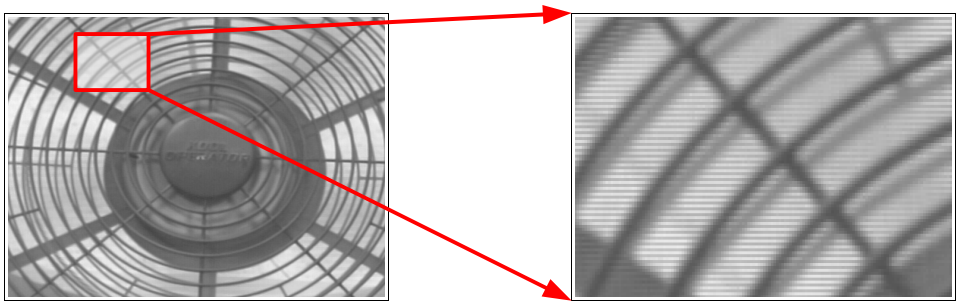

Figure 20: Jaggedness Due to Interlacing (**640x480**)

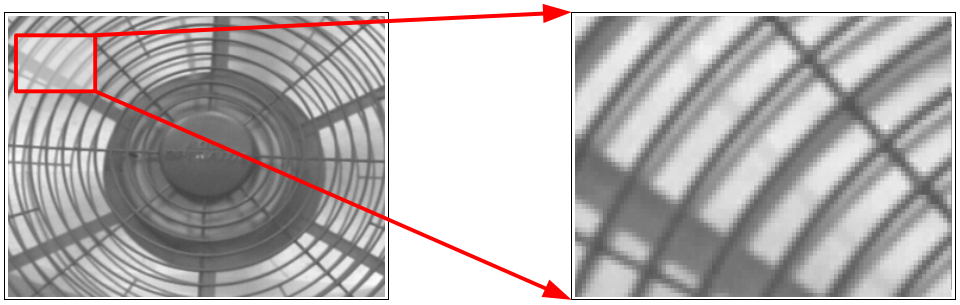

Figure 21: Removed Jaggedness using PSS Mode (**320x240**)

## When to Use PSS

The resulting image acquired using the PSS mode is not interlaced (See Figure 19). PSS mode is especially suitable for motion sensitive applications since it removes the

jaggedness (See Figure 20) inherent in interlaced images. When using PSS mode, the distorting is removed and the resolution is reduced while keeping the same field of view (See Figure 21).

### How to Use PSS

Set the value for **PSS** boolean flag to true in the configuration input to enable PSS. Refer section *How to Set the Configuration* for details.

## Programmable Region of Interest

The Programmable Region of Interest (ROI) feature of the AF-1501 allows the user to transfer a reduced part of the image directly from the hardware without any additional image processing. Figure 22 shows an example of how the programmable ROI works.

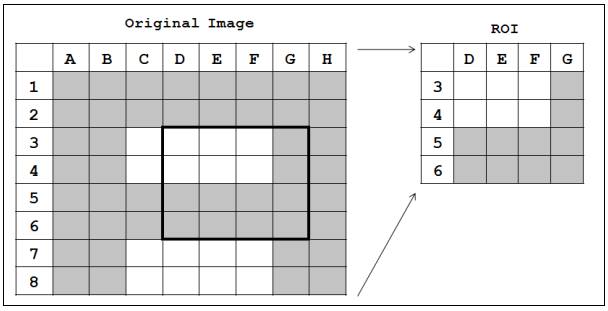


Figure 22: Region of Interest

The frame rate will be affected by the use of a ROI. A smaller ROI will increase the frame rate up to the maximum frame rate (dependent on the video standard used), and a larger ROI will decrease the frame rate.

### When to Use the ROI

The programmable Region of Interest (ROI) feature is especially useful when the user only needs a small part of the image. For instance, if the image activity only happens in the top part of the image, there is no need to transfer anything beyond that region.

If an application requires a higher frame rate without sacrificing bit depth, the image size can be reduced by using a ROI without affecting the application performance.

### How to Use the ROI

First, ROI X0, Y0, X1, and Y1 values need to be determined. Table 2 lists the requirements for using the ROI. The use of Speed Optimized Mode (SOM/4-bit) requires

the ROI X0 and X1 values to be a multiple of 2. For threshold mode (1-bit), the ROI must be a multiple of 6. If PSS, is used the range is reduced by half. In addition, the image size must be greater than zero.

| Mode | X0 Range | Y0 Range | X1 Range | Y1 Range |
|---|---|---|---|---|
| 8-Bit, PSS disabled | 0 to 639 | 0 to 479 | 1 to 640 | 1 to 480 |
| 4-Bit, PSS disabled | 0, 2, 4, … 638 | 0 to 479 | 2, 4, 6, … 640 | 1 to 480 |
| 1-Bit, PSS disabled | 0, 6, 12, … 630 | 0 to 479 | 6, 12, 18, … 636 | 1 to 480 |
| 8-Bit, PSS enabled | 0 to 319 | 0 to 239 | 1 to 320 | 1 to 240 |
| 4-Bit, PSS enabled | 0, 2, 4, … 318 | 0 to 239 | 2, 4, 6, … 320 | 1 to 240 |
| 1-Bit, PSS enabled | 0, 6, 12, … 312 | 0 to 239 | 6, 12, 18, … 318 | 1 to 240 |

Table 2: Valid Values for the Region of Interest

Second, the first coordinate pair must be to the left and above the second pair.

*Therefore: X1 > X0 and Y1 > Y0.*

Third, the ROI values must be written to the module, and the ROI feature must be enabled. Follow these steps to configure the ROI (See *How to Set the Configuration* and Table 2 for more details):

1. Set a valid ROI X0 value in the configuration.
2. Set a valid ROI X1 value in the configuration.
3. Set a valid ROI Y0 value in the configuration.
4. Set a valid ROI Y1 value in the configuration.
5. Set the ROI boolean flag in the configuration to TRUE to enable the ROI feature.
6. Set the **X Size** and **Y Size** to the difference between the right and left, and bottom and top coordinate values, respectively.

*Note: The ROI values must match the image size.*

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Figure 23: Image without ROI

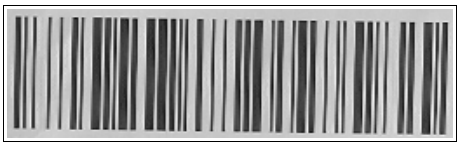

Figure 24: Smaller Image using ROI

## Speed Optimized Mode (4-bit)

The Speed Optimized Mode (SOM) allows the AF-1501 user to reduce bit depth for a higher frame rate. In this mode, the AF-1501 will represent each pixel with four (4) bits instead of the eight (8) bits used the in normal mode of operation. The resulting image will have 14 different gray levels instead of 254 gray levels. As a result, the image transaction (frame rate) will increase. The output image will only use the upper 4-bits for image data when decoded. As a result, the range will still be within 1 to 254 as before, except with a granularity of 16.

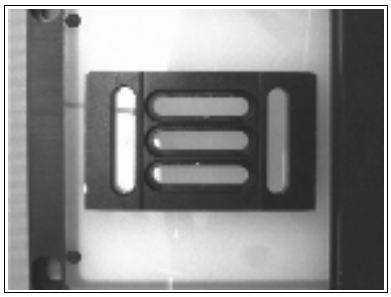

Figure 25: Image of Bracket in 8-Bit Mode

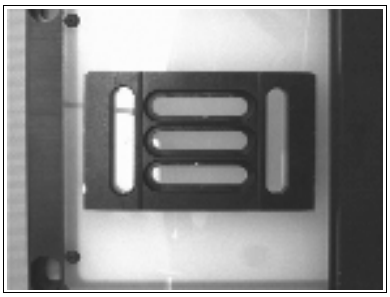

Figure 26: Image in 4-Bit Mode (SOM)

### When to Use SOM

If the imaging application does not require to tell apart gray levels very close together, then SOM mode could be used. The requirement, however, is that the gathered images have a high enough contrast ratio. SOM mode will yield a higher frame rate because the image data is transferred from the module faster at a lower bit depth. Also, SOM can be used to mask image noise occurring in the lower 4 bits of the image.

### How to Use SOM

Set a valid image size with the **X Size** and **Y Size** controls. Select "**4-Bit**" for **Bit-Mode** in the configuration control (See *How to Set the Configuration* for more details).

SeeTable 1 in *Valid Settings* for a list of valid configurations. If the ROI/PSS are enabled, see Table 2 in the section *Programmable Region of Interest* for requirements in this mode.

## Image Inversion

The image data can be optionally inverted. Inversion is performed bit-wise in hardware and is especially useful with the thresholding feature. See Figure 27 and Figure 28 for details:

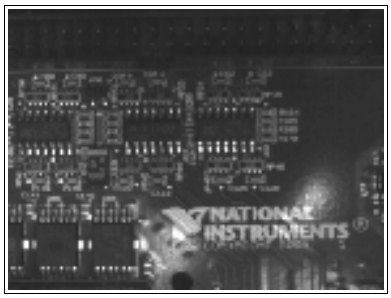


Figure 27: Original Image of a sbRIO PCB

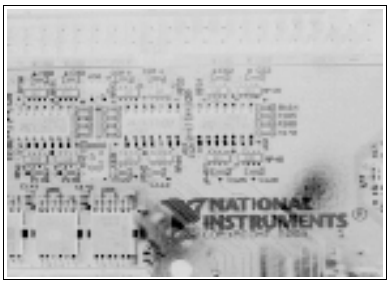


Figure 28: Inverted Image of a sbRIO PCB

### When to Use Image Inversion

Sometimes using a bit-wise inverted image is more convenient than a regular image. One application for this feature is in thermography. Some thermal cameras output data as "black-hot". This means that higher temperature values are encoded as darker pixel values. So, if the application was to locate a hot spot, then the output would need to be inverted if the detection algorithm requires "white-hot" values. Also, it might be more convenient for displaying this type of data with higher temperatures as lighter pixels values.

### How to Use Image Inversion

To enable image inversion, set the **Invert** boolean flag in the configuration settings (See *How to Set the Configuration* for more details). Image inversion feature is compatible with all other features (8-bit, SOM/4-bit, Threshold/1-bit, PSS, ROI) and ignored with the Test Pattern mode.

## Hardware Accelerated Thresholding (1-bit)

The Hardware Accelerated Thresholding feature of the AF-1501 allows the user to do a

binary threshold on the incoming image at the hardware level. This has the effect of masking the image for pixel values within a range. Once the image is threshold-ed, the module outputs a single bit per pixel (1) which results in a notable reduction in transfer time. Figures 32, 31, and 33 show the effects of different threshold settings on a gray-scale image (Figure 30). The same concept is applied in Figure 34 with a real image. Note the shadow is detected in Figure 35 using the low threshold mode. Using both thresholds (See Figure 37) is useful for detecting when parts of an image are in a certain range (windowing) or excluding a range (when image inversion is enabled), for example, in sorting operations. Using the high threshold (See Figure 36) is useful to compensate for black level shift.

There are three different Hardware Accelerated Thresholding options as depicted in Figure 29:

a) Threshold Low: the output value is true if the pixel value is below the Threshold Low value.
b) Threshold High: the output value is true if the pixel value is above the Threshold High value.
c) Both Thresholds: the output value is true if the pixel value is below the Threshold Low value and above the Threshold High value.

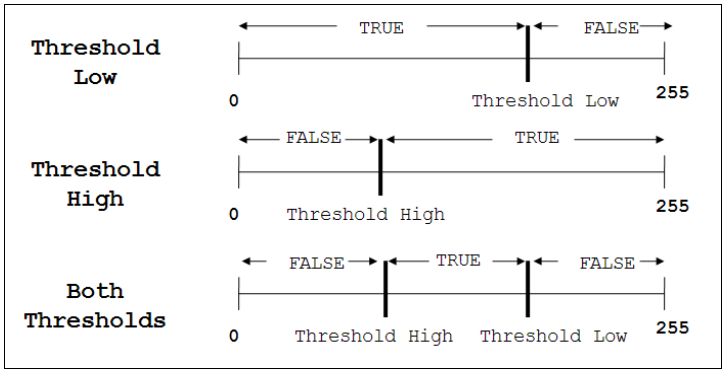


Figure 29: Thresholding

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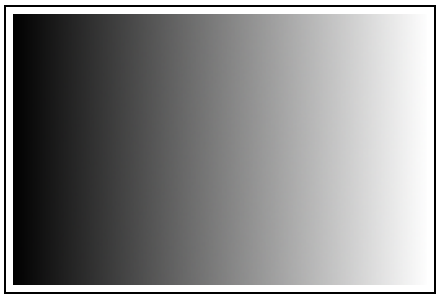


Figure 30: Original Image Before Thresholding

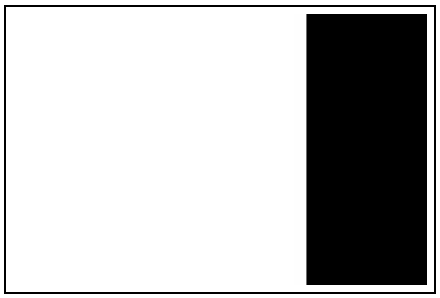


Figure 31: Image After using a Low Threshold of 180

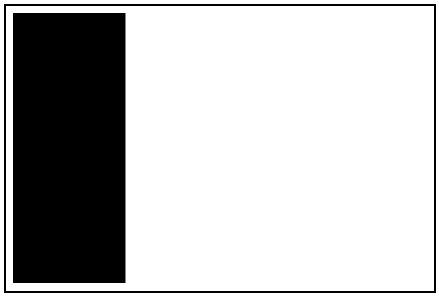


Figure 32: Image After using a High Threshold of 70

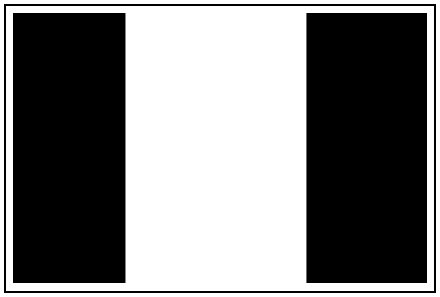


Figure 33: Image After using a Both Threshold Modes (Window)

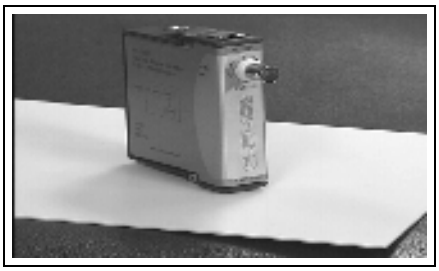


Figure 34: Original Image of AF-1501

Figure 35: Low Threshold of 220

Figure 36: High Threshold of 220

Figure 37: Combined Threshold Modes

### When to Use Threshold Mode

Simple image processing applications can take advantage of the use of Hardware Accelerated Thresholding, for example: finding a white dot in a black background, a robot navigating based on high-contrast fiducial, or thermal alarms when using analog thermal cameras. In general, Thresholding should be enabled when the image has a low contrast ratio. Windowed Hardware Accelerated Thresholding (both high and low thresholds enabled) is especially convenient for simple edge detection. The continuity of the data makes edges to be always in a pixel value range that can be detected using this feature.

### How to Use Threshold Mode

In order to use the Hardware Accelerated Thresholding, the user needs to set the image size, enabled thresholds, and set the bit-depth (See *How to Set the Configuration* for more details). SeeTable 1 in *Valid Settings* for a list of valid configurations. If the ROI/PSS are enabled, see Table 2 in the section *Programmable Region of Interest* for requirements in this mode. Set use Threshold mode, follow these steps:

1. Input a valid image size. (See Table 1 and Table 2).
2. Select the "1-Bit Mode" in the Bit-Mode element on the configuration. Set one of the following threshold mode boolean flags to TRUE: Threshold High, Threshold Low, or Threshold Low and High (Windowing Mode) .

   ⚠ Note: If no threshold filter is selected, the resulting image will be all zero values.
3. Set the Threshold High/Threshold Low or both value(s). Incoherent values could lead to zero or one images, See Figures 29 through 37 to understand the behavior of the thresholding values.

   ⚠ Note: When using IMAQ indicators and Threshold mode images have only two levels (0 or 1) and the user should adjust the palette to binary. This can be done by right-clicking the **IMAQ indicator** and selecting **Palette » Binary**.

## Test Pattern Generator

The AF-1501 can be set to output internally generated test patterns. This feature allows the user to transfer images from the module to the backplane without the need of an analog video source. The test patterns are only available at 640x480 (full) resolution in 8 bit mode. They are not compatible with ROI, PSS, image inversion, or SOM.

The available test patterns are listed and depicted in Table 3:

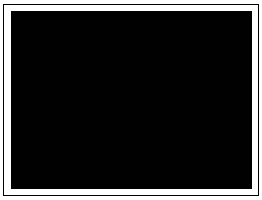
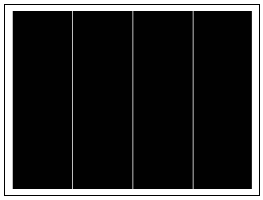
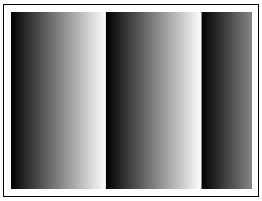
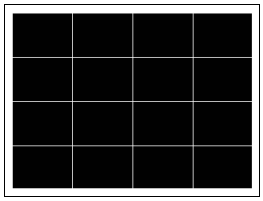
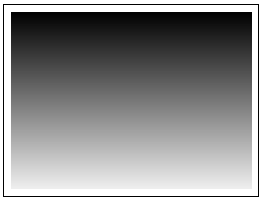
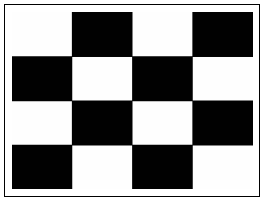
| | | | |
|---|---|---|---|
| 0, All Black |  | 4, Vertical Lines |  |
| 1, Horizontal Gradient |  | 5, Grid |  |
| 2, Vertical Gradient |  | 6, Checkerboard |  |
| 3, Horizontal Lines |  | 7, All White | |

Table 3: Available Test Patterns

**When to Use a Test Pattern**

The test patterns are particularly useful when setting up a system with an AF-1501. If we want to check that the module behaves normally (images transfer correctly) when we have compiled the FPGA driver code and deployed the RT drivers to the target, it is useful to configure the module to output a test pattern. The fact that test patterns are not noisy can also be helpful in particular applications such as: setting reference values, calibration, etc.

**How to Use the Built-In Test Patterns**

In order to use a test pattern, the user needs to set the following values in the configuration (See the *Valid Settings* and *How to Set the Configuration* sections).

1. Set an image size of 640x480.
2. Select the "8-Bit Test Pattern" in the Bit-Mode element on the configuration input.
3. Select the test pattern you want to use in the “Test Pattern” element on the configuration input .

## Feature Inter-compatibility

Table 4 lists the various combinations of features and their compatibility with each other. Multiple features can be used simultaneously. For example, PSS, ROI, and 4-bit (SOM) can be used simultaneously. One example of this would be: **X Size** = 100, **Y Size** = 25, **Mode** = 4-bit, **ROI** = TRUE, **PSS** = TRUE, **ROI X0** = 50, **ROI Y0** = 175, **ROI X1** = 150, **ROI Y1** = 200.

| Mode | PSS | 1-bit | 4-bit | 8-bit | ROI | Invert | Test Pattern |
|---|---|---|---|---|---|---|---|
| PSS | | ☑ | ☑ | ☑ | ☑ | ☑ | ☒ |
| 1-bit | ☑ | | | | ☑ | ☑ | ☒ |
| 4-bit | ☑ | | | | ☑ | ☑ | ☒ |
| 8-bit | ☑ | | | | ☑ | ☑ | ☑ |
| ROI | ☑ | ☑ | ☑ | ☑ | | ☑ | ☒ |
| Invert | ☑ | ☑ | ☑ | ☑ | ☑ | | ☒ |
| Test Pattern | ☒ | ☒ | ☒ | ☑ | ☒ | ☒ | |

Table 4: Special Feature Inter-compatibility Chart

## Sleep Mode

This module supports a low-power sleep mode. Support for sleep mode at the system level depends on the chassis that it is plugged into. Refer to your chassis documentation for information regarding support for sleep mode functionality. You can enable sleep mode in software. Refer to you driver software documentation for more information.

## Specifications

The following specifications are typical for the range –40 °C to 70 °C unless otherwise specified.

## Input Characteristics

Number of channels.....1
Input type.....Analog

Video standards.....NTSC (M,4.43), PAL (B,G,H,I,N,M), SECAM
Internal ADC.....9-bit
Input impedance.....75 Ω ± 1%

## Digital Data Format

Resolution.....1x1 to 640x480
Bit Depth.....8-bit/4-bit/1-bit
Levels.....254/14/2
Real-time OS driver.....IMAQ or Image Array

## Power Requirements

Power consumption from chassis
Active mode (transfer).....1 W max.
Active mode (idle).....350 mW max.
Sleep mode.....<5 mW

## Physical Characteristics

Form factor.....C Series
Weight.....140 g. (5.0 oz.)

## Electromagnetic Compatibility

Emissions.....EN 55022
Immunity.....EN 55024
EMC/EMI.....CE Compliant

## CE Compliance

This product meets the essential requirements of applicable European directives, as amended for CE markings as follows:

Low-Voltage Directive (safety).....2006/95/EC
Electromagnetic Compatibility
Directive (EMC).....2004/108/EC

⚠ *Note: Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information.*

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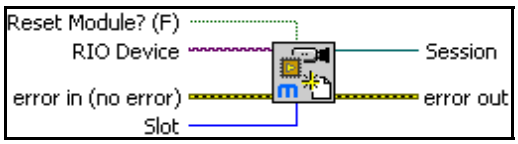
# Application Programming Interface

## Opening a Session to the AF-1501




**Reset Module?** resets the AF-1501 module hardware.
F = Don't Reset Module
T = Reset Module

**RIO Device** selects the RIO target name to open.

**Slot** selects the RIO chassis slot number.

**Session** is the reference number to the open session to the AF-1501.

**error in (no error)** can accept error information wired from VIs previously called. Use this information to decide if any functionality should be bypassed in the event of errors from other VIs. Right-click the error in control on the front panel and select Explain Error or Explain Warning from the shortcut menu for more information about the error.

**status** is TRUE (X) if an error occurred before this VI or function ran or FALSE (check mark) to indicate a warning or that no error occurred before this VI or function ran. The default is FALSE.

**code** is the number identifying an error or warning. If status is TRUE, code is a non-zero error code. If status is FALSE, code can be zero or a warning code. Use the error handler VIs to look up the meaning of this code and to display the corresponding error message.

**source** describes the origin of the error or warning and is, in most cases, the name of the VI or function that produced the error or warning. The default is an empty string.

**error out** passes error or warning information out of a VI to be used by other Vis.

**status** is TRUE (X) if an error occurred before this VI or function ran or FALSE (checkmark) to indicate a warning or that no error occurred before this VI or function ran. The default is FALSE.
Right-click the error in control on the front panel and select Explain Error or Explain Warning from the shortcut menu for more information about the error.

**code** is the number identifying an error or warning. If status is TRUE, code is a non-zero error code. If status is FALSE, code can be zero or a warning code. Use the error handler VIs to look up the meaning of this code and to display the corresponding error message.
Right-click the error in control on the front panel and select Explain Error or Explain Warning from the shortcut menu for more information about the error.

**source** describes the origin of the error or warning and is, in most cases, the name of the VI or function that produced the error or warning. The default is an empty string.

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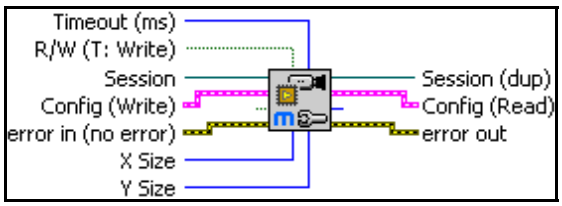
Right-click the error in control on the front panel and select Explain Error or Explain Warning from the shortcut menu for more information about the error.

## Configuration of the AF-1501




**R/W** specifies whether the configuration is to be set or queried. A value of FALSE passed to this VI reads the configuration of the AF-1501 and outputs it to **Configuration (Read)** while a value of TRUE passed writes the configuration passed from **Configuration (Write)** to the AF-1501.

**Timeout** sets the time in milliseconds (ms) for data transfer to/from the AF-1501 to expire and return an error to **error out**.

**X Size** sets the horizontal resolution of the image.

**Y Size** sets the vertical resolution of the image.

**Image Size** returns the area of the image.

**Session** is the reference number to the open session to the AF-1501.

**Session (dup)** is a duplicate of the reference number passed in from **Session**.

**Configuration (Write)** Settings to send to the AF-1501.

**High Threshold**
FALSE : High threshold not used on image data.
TRUE: Output TRUE data if image value is greater than threshold value, otherwise FALSE. If more than one threshold value is enable, the result is logically AND-ed.

**Low Threshold**
FALSE : Low threshold not used on image data.
TRUE: Output TRUE data if image value is less than threshold value, otherwise FALSE. If more than one threshold value is enable, the result is logically AND-ed.

**Channel** selects the which input on the front panel to use (AF-1502/AF-1502C only).

**Invert** Inverts the image.

**Bit Mode** Selects the output bit depth or test pattern.

| | |
|---|---|
| 0 | 8-Bit Mode (Normal) |
| 1 | 4-Bit Mode (SOM) |
| 2 | 1-Bit Mode (Threshold) |
| 3 | 8-Bit Test Pattern Mode |

**Region of Interest** Enables hardware image cropping (ROI) with values in ROI registers.

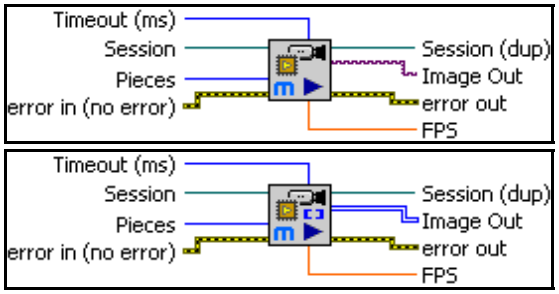
**Progressive Skip Sampling** If a value of FALSE is passed, the output screen resolution is normal, and if a value of TRUE is passed, the output screen resolution is reduced in half.

FALSE = Normal output
TRUE = Skip every other pixel

**ROI X0** Top left window horizontal pixel value
**ROI X1** Bottom right window horizontal pixel value
**ROI Y0** Top left cropping window vertical pixel value
**ROI Y1** Bottom right cropping window vertical pixel value
**Threshold (Low)** Lower threshold value
**Threshold (High)** High threshold value

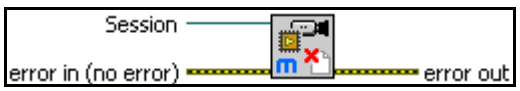
**Configuration (Read)** Settings read from the AF-1501. (same as previous).
**error in (no error)** (same as previous).
**error out** (same as previous).

## Grabbing Images from the AF-1501




**Session** is the reference number to the open session to the AF-1501.
**Session (dup)** is a duplicate of the reference number passed in from **Session**.
**Timeout** sets the time in milliseconds (ms) for data transfer to/from the AF-1501 to expire and return an error to **error out**.
**Image Out** returns a reference to the IMAQ image.
or
**Image Out** returns the image as a 2D array of unsigned 8-bit integers (U8).
**Pieces** is the number of fragments to transfer an image from the frame buffer.
**FPS** returns the calculated frame rate of the image during transfer.
**error in (no error)** (same as previous).
**error out** (same as previous).

## Closing a Session to the AF-1501

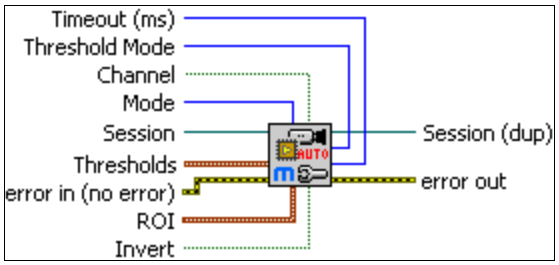



**Session** is the reference number to the open session to the AF-1501.
**error in (no error)** (same as previous).

**error out** (same as previous).

# Advanced API Functions

## Using Auto Configure




**Mode** sets the mode from a list of image settings:

| | | | | | |
|---|---|---|---|---|---|
| 0 | 640x480x8 | 8 | 1-Bit using ROI | 16 | Horizontal Lines |
| 1 | 640x480x4 | 9 | 8-Bit using ROI and PSS | 17 | Vertical Lines |
| 2 | 636x480x1 | 10 | 4-Bit using ROI and PSS | 18 | Grid |
| 3 | 320x240x8 | 11 | 1-Bit using ROI and PSS | 19 | Checkerboard |
| 4 | 320x240x4 | 12 | Separator (same as 0) | 20 | All White |
| 5 | 318x240x1 | 13 | All Black | 21 | Separator (same as 0) |
| 6 | 8-Bit using ROI | 14 | Horizontal Gradient | 22 | Reserved (same as 0) |
| 7 | 4-Bit using ROI | 15 | Vertical Gradient | 23 | Reserved (same as 0) |

**Threshold** sets the thresholding mode.

| | |
|---|---|
| 0 | Low Threshold |
| 1 | High Threshold |
| 2 | Threshold Window (Both) |

**Thresholds** sets the thresholding values.

U8 **Threshold (Low)** Lower threshold value

U8 **Threshold (High)** High threshold value

TF **Channel** selects the which input on the front panel to use (AF-1502/AF-1502C only).

TF **Invert** Inverts the image.

**ROI** sets the Region of Interest.

U16 **ROI X0** Top left window horizontal pixel value.

U16 **ROI X1** Bottom right window horizontal pixel value.

U16 **ROI Y0** Top left cropping window vertical pixel value.

U16 **ROI Y1** Bottom right cropping window vertical pixel value.

**Thresholds** sets the thresholding values.

I32 **Timeout** sets the time in milliseconds (ms) for data transfer to/from the AF-1501 to expire and return an error to **error out**.

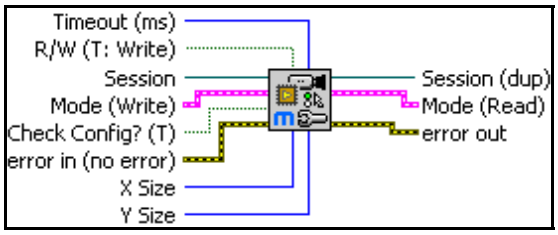
**Session** is the reference number to the open session to the AF-1501.

**Session (dup)** is a duplicate of the reference number passed in from **Session**.

**error in (no error)** (same as previous).

**error out** (same as previous).

## Configuring the Image Mode




**R/W** specifies whether the configuration is to be set or queried. A value of FALSE passed to this VI reads the configuration of the AF-1501 and outputs it to **Mode (Read)** while a value of TRUE passed writes the configuration passed from **Mode (Write)** to the AF-1501.

**Timeout** sets the time in milliseconds (ms) for data transfer to/from the AF-1501 to expire and return an error to **error out**.

**X Size** sets the horizontal resolution of the image.

**Y Size** sets the vertical resolution of the image.

**Session** is the reference number to the open session to the AF-1501.

**Session (dup)** is a duplicate of the reference number passed in from **Session**.

**Mode (Write)** Settings to send to the AF-1501.

**High Threshold**
FALSE : High threshold not used on image data.
TRUE: Output TRUE data if image value is greater than threshold value, otherwise FALSE. If more than one threshold value is enable, the result is logically AND-ed.

**Low Threshold**
FALSE : Low threshold not used on image data.
TRUE: Output TRUE data if image value is less than threshold value, otherwise FALSE. If more than one threshold value is enable, the result is logically AND-ed.

**Channel** selects the which input on the front panel to use (AF-1502/AF-1502C only).

**Invert** Inverts the image.

**Bit Mode** Selects the output bit depth or test pattern.

| | |
|---|---|
| 0 | 8-Bit Mode (Normal) |
| 1 | 4-Bit Mode (SOM) |
| 2 | 1-Bit Mode (Threshold) |
| 3 | 8-Bit Test Pattern Mode |

**Region of Interest** Enables hardware image cropping (ROI) with values in ROI registers.

**Progressive Skip Sampling** If a value of FALSE is passed, the output

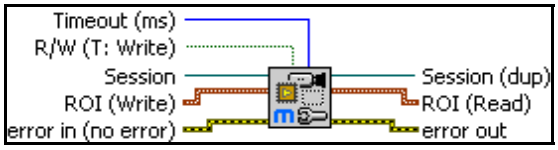
screen resolution is normal, and if a value of TRUE is passed, the output screen resolution is reduced in half.
FALSE = Normal output
TRUE = Skip every other pixel

**Mode (Read)** Settings read from the AF-1501. (same as previous).

**error in (no error)** (same as previous).

**error out** (same as previous).

## Configuring the Region of Interest




**R/W** specifies whether the configuration is to be set or queried. A value of FALSE passed to this VI reads the configuration of the AF-1501 and outputs it to **ROI (Read)** while a value of TRUE passed writes the configuration passed from **ROI (Write)** to the AF-1501.

**Timeout** sets the time in milliseconds (ms) for data transfer to/from the AF-1501 to expire and return an error to **error out**.

**Session** is the reference number to the open session to the AF-1501.

**Session (dup)** is a duplicate of the reference number passed in from **Session**.

**ROI (Write)** Settings to send to the AF-1501.

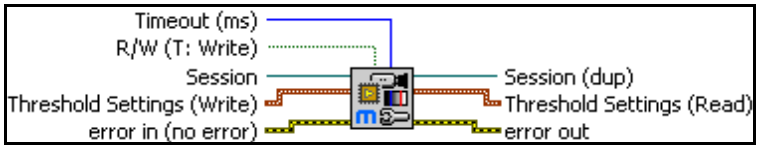
- **ROI X0** Top left window horizontal pixel value
- **ROI X1** Bottom right window horizontal pixel value
- **ROI Y0** Top left cropping window vertical pixel value
- **ROI Y1** Bottom right cropping window vertical pixel value

**ROI (Read)** Settings read from the AF-1501. (same as previous).

**error in (no error)** (same as previous).

**error out** (same as previous).

## Configuring the Threshold Levels




**R/W** specifies whether the configuration is to be set or queried. A value of FALSE passed to this VI reads the configuration of the AF-1501 and outputs it to **Threshold Settings (Read)** while a value of TRUE passed writes the configuration passed from **Threshold Settings (Write)** to the AF-1501.

**Timeout** sets the time in milliseconds (ms) for data transfer to/from the AF-1501 to expire and return an error to **error out**.

**Session** is the reference number to the open session to the AF-1501.

**Session (dup)** is a duplicate of the reference number passed in from **Session**.

**Threshold Settings (Write)** Settings to send to the AF-1501.

**Threshold (Low)** Lower threshold value

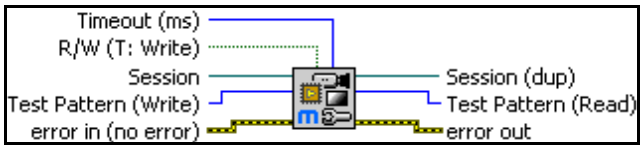
**Threshold (High)** High threshold value

**Threshold Settings (Read)** Settings read from the AF-1501. (same as previous).

**error in (no error)** (same as previous).

**error out** (same as previous).

## Configuring the Test Pattern




**R/W** specifies whether the configuration is to be set or queried. A value of FALSE passed to this VI reads the configuration of the AF-1501 and outputs it to **Mode (Read)** while a value of TRUE passed writes the configuration passed from **Mode (Write)** to the AF-1501.

**Timeout** sets the time in milliseconds (ms) for data transfer to/from the AF-1501 to expire and return an error to **error out**.

**Session** is the reference number to the open session to the AF-1501.

**Session (dup)** is a duplicate of the reference number passed in from **Session**.

**Test Pattern (Write)** Set selected test pattern:

| | |
|---|---|
| 0 | Black Screen |
| 1 | Vertical Gradient |
| 2 | Horizontal Gradient |
| 3 | Vertical Lines |
| 4 | Horizontal Lines |
| 5 | Grid |
| 6 | Checkerboard |
| 7 | White Screen |

**Test Pattern (Read)** Get the selected test pattern. (same as previous).

**error in (no error)** (same as previous).

**error out** (same as previous).