Model 5150
Video Generator Module

User Guide

Issue 1, June 2013

> **This User Guide is applicable for**
> **Model 5150 modules with the following order codes:**
> **M5150, M5150-01, M5150-02, M5150-03X, and M5150-04X**
> **with serial numbers 00151 and later**
> **and firmware versions**
> **MCU 1.3 (m5150.s19) and FPGA 1.2 (m5150.bit)**

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Introduction

The Model 5150 Video Generator Module is a unique device suited for a variety of custom broadcast, post-production, industrial, and corporate multimedia installations. As a member of the 5100-Series of modules, the Model 5150's compact size belies its powerful video feature set. Advanced circuitry within the Model 5150 supports the generation of a broadcast-standard high-definition SDI signal. And rather than reproducing a fixed test pattern, the Model 5150 has the capability to store and output two custom video images. The images, one for "720" and one for "1080," are based on bitmap (.bmp) files that can be created using a personal computer's graphics program.

For convenience, the .bmp files are loaded into the module's nonvolatile memory via a standard USB flash drive. The appropriate "720" or "1080" image is automatically connected to the SDI output whenever an SDI input signal is not present. This ensures that an SDI output signal is always sent to equipment further along the signal chain.

The Model 5150's video signal generation capability can be extremely useful, serving as both a "keep-alive" signal as well as allowing a detailed graphics image to be displayed for identification purposes. To clarify, when a valid HD- or 3G-SDI signal is connected to the module's input it will pass through, unchanged, to the module's SDI output. Only when an input is not present will the custom image be generated. The format and rate of the custom image will match that of the previously-connected SDI input signal. This "learning" capability allows a Model 5150 to automatically adapt to the SDI format and rate utilized by a specific facility or application.

General Highlights

Applications for the Model 5150 include sports broadcasting booth packages, "POV" (point-of-view) remote-controlled camera systems, stadium video interface (I/O) locations, and government/corporate facilities. The module's performance is completely "pro" with video quality, reliability, and installation flexibility matching that of much larger-scale equipment.

For operation the Model 5150 only requires connection of a few signals. These consist of SDI inputs and outputs, an external source of nominal 12 volts DC and, optionally, two wires associated with a local RS-485 data bus. Coaxial SDI input and output support is standard. Optical input and output support is optional. The acceptable DC input voltage range is 10 to 18, allowing a variety of power sources to be utilized.

Figure 1. Model 5150 Video Generator Module front and rear views

The Model 5150 uses standard connectors for fast, convenient interfacing. Coaxial SDI input and output signals use BNC connectors. An optional video SFP fiber optic module can be installed at the factory. The module supports interconnection of single-mode optical fibers using LC plugs. The DC power input and data bus connections use a 4-position, 0.1-inch header. Low-cost IDC (insulation-displacement connector) mating sockets allow simple interconnection with a variety of wire gauges. Four status LEDs offer users both performance confidence and troubleshooting assistance.

The Model 5150 is compatible with the Studio Technologies' Model 5190 Remote Access Module. This will allow remote monitoring and control, via an Ethernet connection, of key module operating and status parameters. A local RS-485 data bus allows up to 16 of the 5100-Series modules to be connected to a Model 5190.

Several switches are accessible during installation and allow configuration of key operating parameters. Updating the Model 5150's firmware (embedded software) is possible using a USB flash drive loaded with personal-computer-compatible files.

Model 5150 Video Generator Modules do not include a mounting enclosure or chassis. They are intended for mounting in custom 19-inch rack panels, equipment boxes, broadcast furniture, "NEMA" I/O boxes, or other specialized enclosures. It is expected that integration firms will create applications that use Model 5150 modules as part of complete broadcast, production, corporate, and government solutions. Sophisticated users will be able to easily create "one-off" solutions to solve unique challenges.

SDI Inputs and SDI Outputs

High-definition SMPTE-compatible SDI signals with data rates of 1.485 Gb/s nominal (HD-SDI) and 2.97 Gb/s nominal (3G-SDI) can be connected. Virtually all of the commonly-utilized "720" and "1080" formats are supported. Standard-definition SDI signals with a data rate of 270 Mb/s nominal (SD-SDI) are not supported. It was felt that users looking for advanced solutions such as provided by the Model 5150 will not typically be working with SD-SDI signals. But be assured that many HD-SDI and 3G-SDI formats and rates are supported, allowing the Model 5150 to be appropriate for worldwide use.

Coaxial (BNC) Support

Using standard BNC connectors, the Model 5150 supports one coaxial SDI input and one coaxial SDI output.

Optical Fiber Support

Factory-implemented options allow the Model 5150 to support SDI signals that are transported using single-mode optical fibers. Using video SFP modules a range of optical input, output, and transceiver capabilities can be supported. For a list of available Model 5150 versions refer to Appendix A.

The standard 1310 nanometer optical transmit wavelength is available, as are the more-esoteric CWDM wavelengths. When a Model 5150 has been provided with an optical SDI input from the factory a configuration choice selects whether it, or the coaxial (BNC) input, is active. A module that includes an optical SDI output will always have its optical output active, transporting the same SDI data as that present on the coaxial (BNC) output.

Video Generation Capability

During typical operation an HD- or 3G-SDI signal is connected to the Model 5150's SDI input. It's then "passed through" to the module's SDI output and on to the next part of the signal chain. But what happens when the external SDI signal is not present? That's when the Model 5150's internal SDI generator becomes active. When a signal is not present on the SDI input the module will generate a high-definition (HD- or 3G-SDI) image that will serve as a "slate," ID, or "SDI-active" signal.

From the factory two bitmap (.bmp) image files are stored in nonvolatile memory. One file is used for generating the image for 1280 x 720 pixel formats and the other for 1920 x 1080 pixel formats. But alternate bitmap image files can be created and stored in the Model 5150. These alternate images can supply site- or application-specific information useful to "downstream" users. Using a personal-computer graphics program, such as Microsoft® Paint® or Adobe® Photoshop®, generating custom images and storing them in the appropriate bitmap format is a simple matter.

A USB port, located on the Model 5150's front panel, allows direct connection of a standard USB flash drive. If the Model 5150's firmware (embedded software) recognizes compatible FAT32 bitmap (.bmp) files on the USB flash drive they will be automatically loaded into nonvolatile memory. The USB flash drive can then be removed with the custom images safely stored within the Model 5150.

One subtle but important feature has been included for situations where the Model 5150's output is used in on-air broadcast applications. When a signal is removed from the module's SDI input, the Model 5150 will output a few seconds of solid-gray color before the stored image appears. This will help to ensure that technicians or operators will be visually "warned" that the module's input signal has been lost and that the custom image will soon be taking its place. It's hoped that the gray video image will be innocuous for on-air viewers yet different enough to encourage operators to switch the module's output away from being "on air."

A unique feature of the Model 5150 is its ability to automatically adapt to the format and rate of a connected SDI signal. This allows the custom image to be output at the same format and rate as that used by the associated network, local facility, or event. If, for example, a connected input is "1080i/59.94" then the Model 5150 will automatically detect and store that information. From then on whenever an SDI input signal is not present the internal generator will output the custom image at "1080i/59.94." Changing the format and rate of the generator only requires connection of an SDI signal with the desired characteristics. (A minimum required connection time helps to ensure that an accidental format/rate change won't occur.) However, there may be situations where maintaining the format and rate of the internally-generated signal is important. To support this condition one configuration choice allows the automatic format/rate selection function to be disabled.

Installation

Integration of the Model 5150 into a selected application should prove quite simple, only connecting SDI input and output signals as well as DC power is required.

Some applications will also require connection to the module's data bus. The coaxial (BNC) input and output connections are compatible with most HD-SDI and 3G-SDI signals. If the specific Model 5150 being installed also includes optical support one or two single-mode fiber interconnections will be made. The fiber connections utilize miniature LC plugs.

The DC power source is nominal 12 volts with an acceptable range of 10 to 18 volts. It's possible that the module will be part of a local RS-485 data bus that's associated with a Studio Technologies' Model 5190 Remote Access Module. If so, two additional wires are required to connect the module to the data bus. After the connections have been completed the module can then be secured into the designated mounting location.

Coaxial (BNC) SDI Output

The Model 5150 provides an SDI output that utilizes a broadcast-standard BNC socket. This output is referred to as the coaxial (BNC) SDI output. Refer to Figure 2 for a detailed view of the connector's location on the rear of the module. The coaxial (BNC) output, depending on operating conditions, will be either an SMPTE-compliant HD-SDI (1.485 Gb/s nominal) or 3G-SDI (2.97 Gb/s nominal) signal. The exact format/rate combinations supported by the Model 5150 are listed in the Specifications section of this guide.

Coaxial (BNC) SDI Input

An SDI source can be connected to the Model 5150 by way of a broadcast-standard BNC connector. This is referred to as the coaxial (BNC) SDI input. Refer to Figure 2 for a detailed view of the connector's

location on the rear of the module. The coaxial (BNC) input is compatible with SMPTE-compliant HD (1.485 Gb/s nominal) and 3G (2.97 Gb/s nominal) SDI signals. It is not compatible with standard definition SD-SDI (270 Mb/s nominal) signals. The exact format/rate combinations supported by the Model 5150 are listed in the Specifications section of this guide.

A configuration switch setting must be made for the coaxial (BNC) SDI input to be active. Refer to the Configuration section of this guide for details.

Optical SDI Output

This section applies only when the specific Model 5150 module being installed was configured at the factory to provide an optical output. A video SFP (small form-factor pluggable) optical module is used to provide the optical SDI output. A range of SFP modules can be installed in the "cage" at the back of the Model 5150. These include transceiver modules that have both an optical output (transmitter) and an optical input (receiver), as well as output-only (transmitter) modules. The technical characteristics of the optical output will depend on the specific module installed. The most common transceiver or output-only SFP module used in the Model 5150 will have an FP (Fabry-Perot) laser emitting "light" at a wavelength of 1310 nanometers. Other modules can utilize a higher-performance DFB (distributed feedback) laser that is manufactured to produce light at one of the 18 CWDM wavelengths. (For broadcast applications, the common first-utilized CWDM wavelengths are often 1490 and 1550 nanometers.)

An LC plug terminated on a single-mode optical fiber is used to mate with the SFP's optical output. When referenced to the front of an SFP transceiver or output-only SFP module the optical output is located on the SFP module's left side. To indicate the optical output port a graphic arrow icon pointing "out" may be present on the top of the module. Refer to Figure 2 for a detailed view. When terminating the LC plug with the socket on the SFP module be certain that the plastic plug's locking tab is fully engaged into the slot of the SFP module. This will help prevent the LC plug from becoming disconnected due to physical stress or vibration on the fiber. Also ensure that the end ("face") of the plug's ferrule has been cleaned using appropriate methods.

Note that as of the time this user guide was written the Model 5150 supports only single-mode optical cable. Contact Studio Technologies should support for multi-mode fiber be required.

The Model 5150 module should remain without power whenever its optical output has not been terminated. This ensures that the optical energy will not project into free space and possibly into the eyes of installation personnel. The optical output power of video SFP modules selected by Studio Technologies adheres to the class 1 laser standard. As such, they do not emit sufficient power to be considered hazardous. But best safety practices require that the optical output port and all unconnected fiber ends not be directly viewed.

No configuration switches or other settings are required to activate the optical output. It is always active and will contain the same SDI data as that found on the coaxial (BNC) output. As such there is no problem in simultaneously connecting to both the optical and coaxial (BNC) outputs.
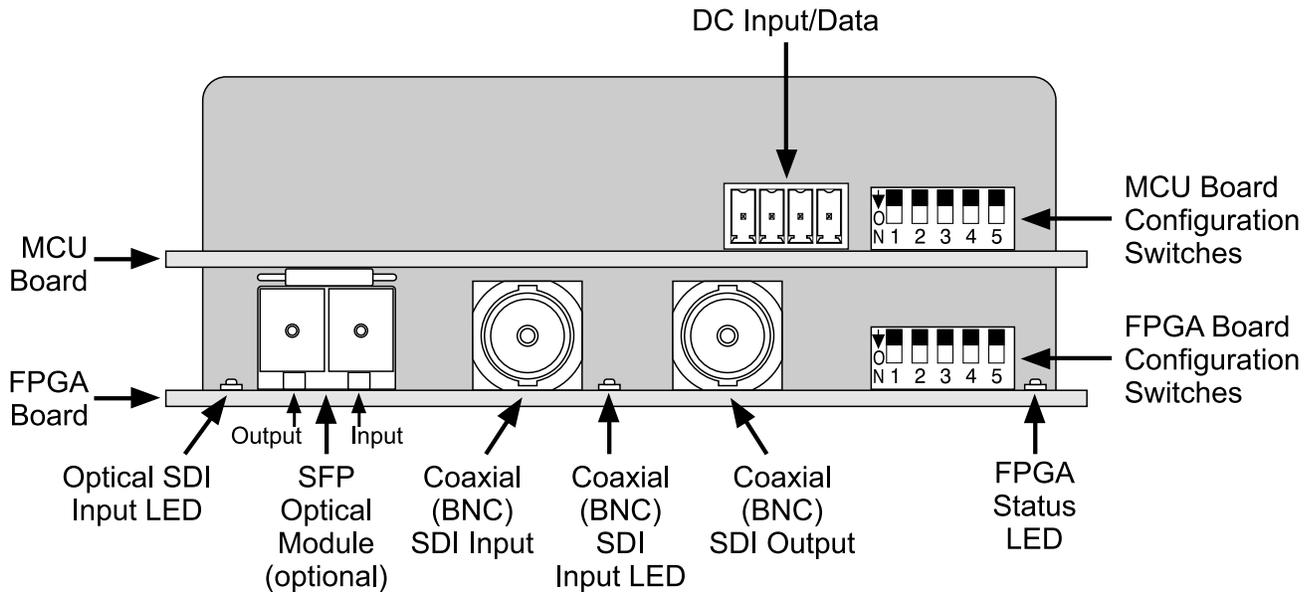

Figure 2. Detailed rear view of the Model 5150 Video Generator Module showing the MCU and FPGA boards

Optical SDI Input

If supported by the specific Model 5150 module being installed, an HD- or 3G-SDI signal transported on a single-mode optical fiber can be connected. For an input to be present a video SFP transceiver or a receive-only SFP module must have been installed in the SFP "cage" in the back of the unit. The optical receiver circuitry in an SFP module is "broadband" and doesn't need to receive a specific wavelength of single-mode optical signal for correct operation. As long as the optical signal has a wavelength between 1250 and 1650 nanometers and meets the applicable SMPTE standards it will be recognized correctly.

A single-mode optical fiber terminated with an LC plug can be connected to the receive port on the SFP module. This port is on the right side when looking directly at the back of the SFP module. Typically there will be a graphic arrow icon pointing "in" on the top of the module. Refer to Figure 2 for details on the location of the SFP module. Ensure that the LC plug fully "mates" with the receive port and its tab is locked into the slot of the SFP module.

A configuration switch must be appropriately set to enable the optical SDI input. There is no automatic switching between the optical and coaxial (BNC) SDI inputs. Only one of the two SDI inputs can be selected and active at a time. Refer to the Configuration section of this guide for details.

DC Input and Data Bus

A 4-position header is used to connect DC power and a local RS-485 serial data bus to the Model 5150. Two pins on the mating connector are used to connect a source of nominal 12 volts DC. The acceptable range is 10 to 18 volts DC with a maximum current of 400 milliamperes at 12 volts DC. For remote control operation two pins on the mating connector will implement the data bus connection from a Studio Technologies' Model 5190 Remote Access Module.

The mating connector is compatible with the AMP MTA-100 series of IDC receptacles. For 22 AWG wire the closed-end-style receptacle is AMP 3-643813-4; the feed-through-style receptacle, used for busing connections, is AMP 3-644540-4. The body color for both receptacles is red, following the convention of the MTA-100 series for compatibility with 22 AWG wire. Refer to Appendix B of this guide for additional connector details.

1. – DC (Common)

2. + DC (10-18 volts)

3. + Data (RS-485)

4. – Data (RS-485)

Figure 3. DC Input and Data Bus Connections

Mounting

The Model 5150 is intended for mounting in an installation-specific enclosure or rack panel. Refer to Appendix C at the end of this guide for details on the required mounting opening and screw locations. Please contact the factory to discuss mounting options.

Configuration

Seven DIP switches are used to configure the Model 5150's operating functions. The functions relate to SDI input selection, SDI output image format/rate mode, RS-485 address, and moving image overlay. The seven switches are located on the two circuit boards that comprise the Model 5150. Two of the switches are on the FPGA board which is the lower board. (There is a total of five switches on the FPGA board but only two are used to configure Model 5150 functions.) The other five switches are on the MCU board which is the upper board. The switches are a "piano key" type with their up position being defined as off and their down position defined as on.
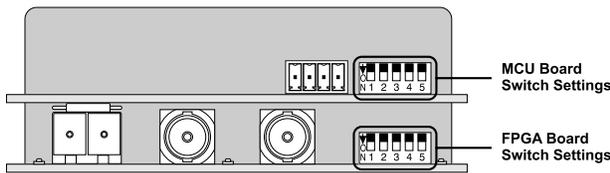

Figure 4. Rear view of Model 5150 showing FPGA and MCU board configuration switches

SDI Input Select

The Model 5150 is capable of having its SDI input in the form of a coaxial signal (BNC connector) or an optical signal (SFP module). All versions of the Model 5150 support the coaxial (BNC) input. The optical input is an option and may or may not be present on the specific module you are configuring.

Switch 1 on the FPGA board is used to select which SDI input is active. When the switch is in its off (up) position the coaxial (BNC) input is selected. When the switch is in its on (down) position the optical input is selected. Of course an optical input will only function if a factory-supplied SFP module is physically present.
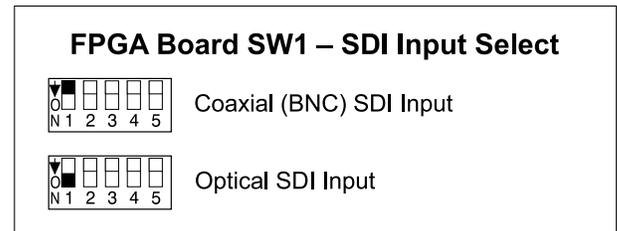

Figure 5. SDI Input Select Settings

SDI Output Image Format/ Rate Mode

Switch 5 on the FPGA board is used to configure how the format and rate of the internal SDI generator is selected. (The internal SDI generator creates the solid-gray video image and plays back the custom "720" and "1080" images.) When the switch is in its off (up) position the format and rate will automatically "follow" that of the connected SDI input. This allows the Model 5150 to automatically "learn" the specific format and rate used by a broadcast facility or live event.
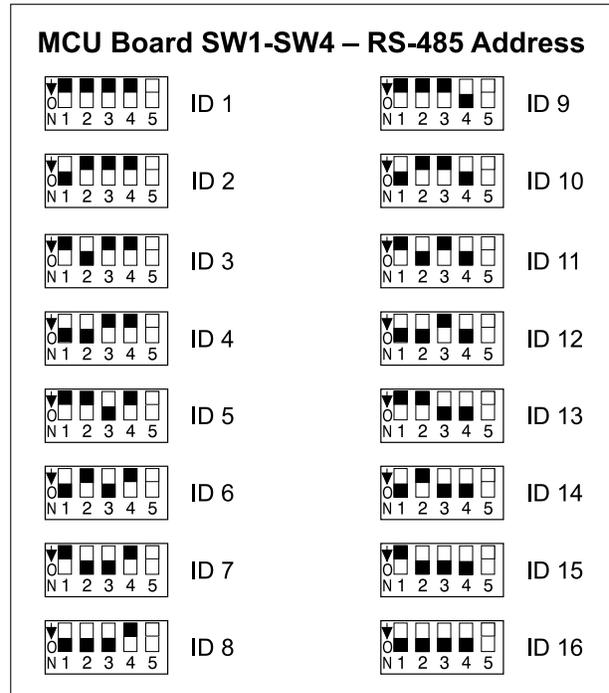
FPGA Board SW5 –
SDI Output Image Format / Rate Mode

Auto Select (Follows Input)

Locked (Does Not Follow Input)
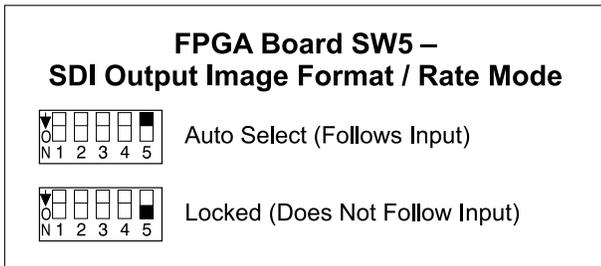
Figure 6. SDI Output Image Format/Rate Mode Settings

The format and rate of the internal SDI generator can also be "locked" so that it will not change. When switch 5 is in its down (on) position the format and rate that's currently being used cannot be changed, no matter what signal is connected to the SDI input.

While the format and rate is "locked" when switch 5 is down, it's not difficult to change the Model 5150 to a different "locked" format and rate. Begin by changing the mode back to automatic by placing switch 5 on the FPGA board to off (up). Then connect (or leave connected) an SDI signal that has the desired format and rate. After approximately five seconds the new format and rate values will be saved in nonvolatile memory. This will serve as the new format/rate parameters. Then return switch 5 to its on (down) position to "lock" the format/rate and prevent further changes.

RS-485 Address

One configuration setting must be performed for applications that implement remote control of Model 5150 functions. While up to 16 Model 5100-Series modules can "share" the RS-485 data bus, each module must have a unique address. Selecting the device's address involves setting four configuration switches on the MCU board.

MCU Board SW1-SW4 – RS-485 Address

ID 1 — ID 9
ID 2 — ID 10
ID 3 — ID 11
ID 4 — ID 12
ID 5 — ID 13
ID 6 — ID 14
ID 7 — ID 15
ID 8 — ID 16

Figure 7. RS-485 Address Settings

Moving Image Overlay

A "moving" graphic image can be overlaid onto the stored "720" and "1080" images when either is being output by the Model 5150. The image is a red-colored box that slowly moves around the screen. This simple icon provides an indication to personnel located downstream of the Model 5150 that the SDI signal is active. This can be important to ensure that a distinction can be made between an active image and an image that's the result of the last valid frame being held and displayed while an SDI input is no longer present.

MCU Board SW5 – Moving Image Overlay

Disabled

Enabled
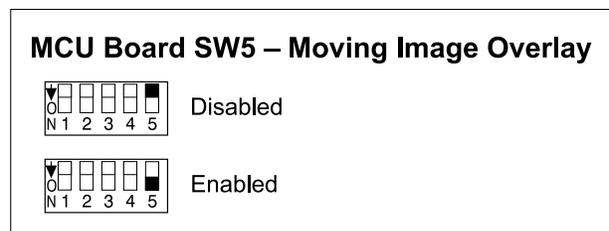
Figure 8. Moving Image Overlay Settings

When switch 5 on the MCU board is in its off (up) position the stored images ("720" and "1080") will be displayed without the moving image being added. When the switch is in its on (down) position the moving image will be added.

Note that the characteristics of the image (color, size, and movement) can't be modified. The image overlay function is created in firmware (embedded software) with no provision for users to alter it.

Operation

Power Up

Upon 12 volt DC power being applied to the Model 5150 the four front-panel LEDs will perform a "walk-through" test, with each LED briefly lighting in sequence. Then the LEDs will light in patterns that represent the version numbers of the firmware (embedded software) files that are loaded into the module. Upon completion, the Power LED will continuously light. For normal operation to commence, prior to powering up the module ensure that a USB flash drive is not plugged into the USB port on the front panel.

LED Indicators

A brief discussion of the Model 5150's status LEDs will be covered in this section.

Front-Panel LEDs

As previously discussed, upon power up the four front-panel LEDs will light in a short sequence as an initialization test. Afterwards they are used to display the version number of the installed MCU and FPGA firmware. Refer to the Technical

Notes section of this guide for details. Following the power-up sequence, the Power LED will light and remain lit.

The USB Activity LED will not light during normal Model 5150 operation. It will be lit continuously or in a pattern when a USB flash drive is plugged into the USB port on the front panel and file transfer activity is taking place. Details on how the LED functions when the USB port is active are covered in the Technical Notes section of this guide.

The SDI Input LED lights whenever a valid SDI signal is connected to the coaxial (BNC) or optical SDI input. (A configuration choice selects whether the coaxial (BNC) SDI input or optical SDI input is active.)

The Data LED will light whenever data activity is taking place over the local RS-485 signal bus that is used to link the Model 5150 to a Studio Technologies' Model 5190 Remote Access Module. The LED will flash on and off each time data associated with this specific Model 5150 is present. Not all applications will include a connection to the data bus so it's certainly possible that the Data LED may never flash except during module power up.

FPGA Board LEDs

Three LEDs are located on the back edge of the FPGA printed circuit board and serve as factory- and field-diagnostic aids. Upon Model 5150 power up each LED will light for several brief durations with no specific meaning associated with them. Then the FPGA Status LED, located adjacent to the configuration switches, will light and remain lit. This indicates that the FPGA and MCU boards are correctly communicating.

The LED located adjacent to the coaxial SDI input's BNC connector will light whenever that input has been configured to be active and a valid SDI signal is connected. It will not light if a valid SDI signal is connected but the SDI input configuration switch is not set to activate the coaxial (BNC) input.

The LED located adjacent to the "cage" that holds the SFP module will light if the optical SDI input has been selected and a valid SDI optical signal is connected. It will not light if a valid optical signal is connected but the SDI input configuration switch is not set to activate the optical input.

A fourth LED is located near the front of the FPGA board. Called the FPGA Done LED, it lights whenever the logic device (FPGA) has loaded its firmware and is operating normally. This LED is provided only for factory troubleshooting use.

Initial SDI Output

After the power-up sequence has been completed the module's SDI output will become active. (This will be both the coaxial (BNC) output and, if present, the optical SDI output.) If a valid signal is connected to the SDI input it will be routed to the SDI output. If a signal is not connected to the SDI input the internal SDI generator will supply a signal to the SDI output. In the latter case, after the Model 5150 power-up sequence has taken place (about seven seconds) a solid-gray image will be output for approximately seven seconds. Then either the custom "720" or "1080" image will be displayed.

SDI Input and SDI Output

Depending on the exact Model 5150 version that has been installed and how it was

configured an SDI signal can be connected to the coaxial (BNC) input or the optical input. When a signal that's compatible with the Model 5150 has been connected the front-panel SDI Input LED will light. This indicates that the signal is being routed to the SDI output and the internal SDI generator is not active. SDI signals that comply with most HD (1.485 Gb/s nominal) and 3G (2.97 Gb/s nominal) standards are compatible. Refer to the Specifications section of this guide for a list of the supported standards.

The Model 5150 always provides an active SDI signal on the coaxial (BNC) output. Some Model 5150 versions also provide an optical output. This is accomplished at the factory by installing one of a variety of available SFP optical modules in the back-panel SFP "cage." If an optical output is present it will always be active and provide an identical copy to the signal present on the coaxial (BNC) output.

If a valid SDI signal is not connected to the selected SDI input the custom image will be present on the coaxial (BNC) output and, if present, optical output. Depending on the stored format and rate values, the output will be either a 1280 x 720 pixel ("720") or 1920 x 1080 pixel ("1080") fixed image.

Stored Images

When a valid signal is not connected to the selected SDI input, the module generates one of two fixed images. The two images, one "720" and one "1080," are stored in nonvolatile memory within the Model 5150. From the factory two images are pre-loaded. The two are quite different from one another with each having a unique photo background and overlaid text.

The overlaid text provides support details on how alternate custom images can be created.

It's expected that these pre-loaded images will be replaced with application-specific images. They can be easily created and what they consist of is limited only by one's imagination. Refer to the Technical Notes section of this guide for details.

Transitions between External and Internal SDI Signals

Whenever a valid SDI signal is connected to the selected Model 5150 input it will immediately be routed to the coaxial (BNC) and, if present, optical SDI outputs. The situation is a little different when a valid signal that's been connected to the SDI input is subsequently removed. When the Model 5150 detects that an SDI input signal is no longer present the SDI output switches to an image with a solid-gray color. This color remains active for approximately seven seconds as a benign warning to users that the normal SDI source is no longer present. During this time period it's expected that any on-air use of the Model 5150's output can be terminated without alerting viewers that anything is amiss. This gray image can also be helpful as a marker when editing recorded video. After the seven-second interval has elapsed the internal generator will output either the "720" or "1080" stored image.

It's important to note that the Model 5150 does not perform a smooth transition when switching between an external SDI source and the internal SDI generator. The same holds true when the internal color or image generator is active and then a valid source is connected to the SDI input. The SDI output does not stay "locked" during the transition as the circuitry in the Model 5150 was not designed to that level of sophistication. This shouldn't cause an operational issue as the Model 5150 was not designed to be "on air" during those transitions; the changeover process is not seamless by design. One can assume that up to two seconds of interruption will occur during transitions but typically it will be considerably shorter.

Output Format and Rate

When a valid signal is connected to the SDI input it will be routed to the SDI output at the identical format and rate of the source. When the SDI input is no longer present the internally-generated signal will become active and be routed to the SDI output. The format and rate of the internally-generated SDI signal will depend on parameters that are stored within the Model 5150. Whether these parameters can change depends on the configuration of the module's SDI output image format/rate mode. Typically, the mode will be set for Auto Select which allows the Model 5150 to revise its parameters by following the format and rate of the connected SDI signal. This ensures that the Model 5150 can generate an SDI signal that matches the requirements of a facility or event. For the module to "learn" a new format and rate simply requires the momentary connection of an SDI signal that has the desired format and rate. As long as the signal is present on the SDI input for a minimum of five seconds the Model 5150 will store the "new" format and rate parameters in nonvolatile memory. The module will then use those parameters whenever the internal generator is active. The only caveat for the module to "learn" a new format/rate

combination is that it must be a compatible combination. Refer to the Specifications section of this guide for a complete list.

There are some applications that will benefit from the internally-generated SDI output signal always having a specific format and rate. In this case the SDI output image format/rate mode can be set for Locked. No matter what the format and rate of a connected SDI signal, the stored parameters will not change. Changing the stored parameters would require the format/rate mode to be changed to Auto Select, an SDI signal with the desired format and rate be connected for a minimum of five seconds, and then the format/rate mode changed back to Locked.

Moving Image Overlay

The Model 5150 has the ability to overlay a moving image on top of the stored "720" and "1080" images. A configuration setting selects whether the moving image overlay will be active. The moving image, a box that's red in color, slowly moves around and on top of whatever stored image is present on the SDI output. The color, size, and rate of motion of the "box" are fixed in the FPGA's firmware (embedded software) and can't be altered.

The moving image is provided specifically so that users who are "downstream" from the Model 5150's SDI output are assured that the "720" or "1080" image they are viewing is active. And, just to clarify, if a signal is present on the Model 5150's selected SDI input it will be passed on to the coaxial (BNC) and, if present, optical SDI outputs. The moving image will never overlay an input signal—it can only overlay on top of the stored image.

Technical Notes

Bitmap Image File Requirements

The Model 5150 allows two bitmap (.bmp) images to be stored and output when an SDI input signal is not present. One image has a pixel size of 1280 x 720 while the other has a pixel size of 1920 x 1080. To be stored with the Model 5150 the files must be FAT32-compatible and have names of **img720.bmp** and **img1080. bmp**, respectively.

The reason two files are required is simple: the Model 5150 does not have the ability to digitally "scale" a 1920 x 1080 image down to 1280 x 720. But it does have the ability to store two unique files. Most users will create a single image using a personal-computer graphics program and then save it in the two required formats. So when the Model 5150 generates either of the two images ("720" or "1080"), a user will see what appears to be an identical image. But there is no reason why the two images ("720" and "1080") have to be based on the same original graphics. Studio Technologies chose to create two different "720" and "1080" bitmap files that are pre-loaded in the Model 5150 at the time of manufacture. They feature two unique background images with text highlighting the main requirements for updating them.

While the two bitmap files (**img720.bmp** and **img1080.bmp**) are "standard" in the sense that they are FAT32-compatible and have the extension .bmp, they must adhere to one important requirement that not all personal-computer graphics programs support. Their DIB (bitmap information header) must be a BITMAPINFOHEADER type.

The Microsoft Paint and Adobe Photoshop applications will create .bmp files that meet this requirement. But some other programs may produce non-compatible files. For example, the open-source GIMP graphics program is very good but appears to save .bmp files only as a BITMAPV4HEADER type. These are not compatible with the Model 5150. The possibility that various .bmp files will have different header types doesn't seem to be an issue for displaying them successfully with most personal-computer programs. This is most likely due to the PC's large code space allowing essentially all the possible header types to be supported. But the Model 5150, due to its target application, has limitations in the file support area. (For additional background information, please refer to the Wikipedia online entry that discusses the structure of .bmp files.)

A compatible 1280 x 720 ("720") .bmp file created using Microsoft Paint or Adobe Photoshop will have a size of approximately 2.63 MB; a 1920 x 1080 ("1080") .bmp file will have a size of approximately 5.63 MB. The actual size of the files when created in Microsoft Paint should be 2,764,854 bytes and 6,220,854 bytes, respectively. When created in Adobe Photoshop, the file sizes should be 2,764,856 bytes and 6,220,856 bytes, respectively. (Why are they each two bytes in size different? Who knows! But both use the appropriate BITMAPINFOHEADER DIB type.)

Bitmap Image Update Procedure

It's expected that the Model 5150's bitmap (.bmp) files associated with the custom "720" and "1080" images will always be updated to best serve specific applications. This will typically take place soon after a

Model 5150 has been installed. (While the pre-loaded images are nice, they aren't really appropriate for actual active applications.) There's no problem changing the files whenever the application warrants alternate images. The module has the ability to automatically load revised files by way of its USB interface. The Model 5150 implements a USB host function that directly supports connection of a USB flash drive.

Updating the Model 5150's "720" and "1080" images is quite simple but requires some care. The process begins by preparing a USB flash drive. The flash drive doesn't have to be empty (blank) but must be in the personal-computer-standard FAT32 format. Save the new image (.bmp) files in the root directory. Their names must be **img720.bmp** and **img1080.bmp**. Typically both .bmp files will be updated at the same time. But there's no requirement to do so. Individual files can be updated whenever desired. Simply copy the desired file or files to the root directly on the USB flash drive. Be certain that there are no Model 5150 firmware files (**m5150.s19** and **m5150.bit**) present on the USB flash drive during this process.

As previously reviewed in this guide, the 1280 x 720 image must have a file name of **img720.bmp**; the 1920 x 1080 image must have a file name of **img1080.bmp**. Also ensure that both have the DIB header type BITMAPINFOHEADER so that they can be recognized correctly by the Model 5150.

To install the new image files:

1. Power down the Model 5150 module.

2. Insert the prepared USB flash drive into the module's USB port.

3. Apply power to the module.

4. The module will go through its power-up LED sequence and normal operation will begin. At about the same time that normal operation starts the new .bmp files will begin to load, one after the other. The USB Activity LED on the module's front panel will flash while the loading process is taking place. Loading both .bmp files will take approximately 6.5 minutes. (Loading only the **img720.bmp** file takes approximately 2 minutes; loading only the **img1080.bmp** file takes approximately 4.5 minutes.) Once the loading process has been completed the USB Activity LED will change from flashing to being continuously lit.

Note: If the module is currently outputting one of the stored images and a new image of the same type ("720" or "1080") has just completed loading, the output will automatically change to the new image. (It's possible that a few seconds of a solid color could be output during the transition from the old image to the new image.)

5. Power down the module.

6. Remove the USB flash drive from the module's USB port.

7. Power up the Model 5150 module. It will go through its normal power-up LED sequence and begin operation. It will use the updated images whenever the internal SDI generator is active.

It's possible that during the update process any LEDs located on the USB flash drive may light steadily or flash with varying patterns. These actions are not significant to the Model 5150's update procedure. (The status LEDs on various USB flash drives seem to behave in different ways so there are no universal patterns that can be identified.)

Firmware Update Procedure

It's possible that updated versions of the firmware (embedded software) that runs the Model 5150 will be released to add features or correct issues. The module has the ability to automatically load revised files by way of its USB interface. The Model 5150 implements a USB host function that directly supports connection of a USB flash drive. The Model 5150 uses two firmware files to perform its functions. One file is used by the microcontroller integrated circuit (MCU) and has a file name of **m5150.s19**. The microcontroller is the overall "boss" of the Model 5150, doing pretty much everything but the SDI-related tasks. The other firmware file is used by the logic chip (FPGA) and has a name of **m5150.bit**. This firmware, running in the FPGA, creates the video images and processes the SDI signals. The factory will provide updates of these firmware files if it's warranted for your specific Model 5150 module.

To update the Model 5150's firmware is quite simple but requires careful execution. The process begins by preparing a USB flash drive. The flash drive doesn't have to be empty (blank) but must be in the personal-computer-standard FAT32 format. Save the new firmware files in the root directory. Their names must be **m5150.s19** and **m5150.bit**. Be certain that any custom image files (**img720.bmp** and **img1080. bmp**) are not present on the USB flash drive during this process.

Studio Technologies will supply the MCU and FPGA files inside individual .zip archive files. While the firmware file inside of each zip file will adhere to the naming convention required by the Model 5150, the name of the zip file itself will include the version number. For example, a file named **m5150v1r2MCU.zip** would indicate that version 1.2 of the MCU firmware (**m5150.s19**) is contained within this zip file; a file named **m5150v1r1FPGA.zip** would indicate that version 1.1 of the FPGA (**m5150.bit**) is contained within this zip file. The version numbers of the files that are copied to the USB flash drive should be noted for later reference. Once the new files are loaded into a Model 5150 the module's front-panel LEDs should be used to confirm that the correct firmware versions have been successfully installed.

Note: The firmware update procedure itself will not erase or overwrite bitmap image files that are already saved in the Model 5150. However, this requires that the custom image files (**img720.bmp** and **img1080.bmp**) are not present on the USB flash drive.

To install the firmware files:

1. Power down the Model 5150 module you intend to upgrade.

2. Ensure nothing is inserted into the USB port on the module. Power up the module and "read" the version numbers of the currently-installed MCU (**m5150.s19**) and FPGA (**m5150.bit**) files. Write these numbers down for reference. The next section of this guide details how to "read" the installed firmware version levels.

3. Power down the Model 5150 module.

4. Insert the prepared USB flash drive into the module's USB port.

5. Apply power to the Model 5150 module.

6. The module will run a "boot loader" program that will immediately load the new MCU (**m5150.s19**) file. This takes approximately six seconds. Once the file is loaded the module will perform a normal power-up sequence with the microcontroller using its newly-loaded MCU firmware.

7. After the power-up sequence has been completed the module will begin operation. It will process video as well as checking for an FPGA (**m5150.bit**) file on the USB flash drive. If it doesn't find this file normal operation will continue. If it locates this file it will begin to load it from the USB flash drive. In that case, some Model 5150 functions will halt, including reading changes to the configuration switches. As an indication that the file transfer is under way, the USB Activity LED will flash on and off.

8. The process of loading the FPGA (**m5150.bit**) file will take approximately 90 seconds to complete. When the file loading process is complete you will see the module's front-panel USB Activity LED change from flashing to being continuously lit. At that time the Model 5150's logic chip (FPGA) will reboot and run under the newly-loaded firmware.

9. Power down the module.

10. Remove the USB flash drive from the module's USB port.

11. Power up the Model 5150 module and it will begin operation using the updated MCU and FPGA firmware. The version numbers of the installed MCU and FPGA firmware should be "read" by way of the front-panel LEDs. Compare and confirm that these numbers match those from the zip file names that were provided by the factory.

Note: It's possible that during the update process any LEDs located on the USB flash drive may light steadily or flash with varying patterns. These actions are not significant to the Model 5150's firmware update process. (The status LEDs on various USB flash drives seem to behave in different ways so there are no universal patterns that can be identified.)

Identifying the Installed Firmware Versions

The four status LEDs on the front panel of the Model 5150 are used during the power-up sequence to identify the version number of the installed MCU and FPGA firmware (embedded software). While the display method is a bit unique, once a user gets accustomed to what's actually happening during power up it should be fairly straightforward to "read" the version numbers.

To identify the installed firmware versions:

1. Power up the Model 5150. The four LEDs will perform a "walk-through" test, with each LED briefly lighting in a sequence.

2. After a slight pause one of the four LEDs will light briefly. This will indicate the major number of the MCU's firmware version. The LED will stop lighting then another one of the four LED will light briefly to indicate the minor number of the MCU's firmware version. The range of each is 1-4. A period (.) is inserted between the major and minor numbers.

    As an example, if the USB Activity LED lights first followed by the SDI Input LED lighting this would indicate version 1.2 of the MCU firmware.

The **USB Activity** LED lights to represent the number **1**

The **SDI Input** LED lights to represent the number **2**

The **Power** LED lights to represent the number **3**

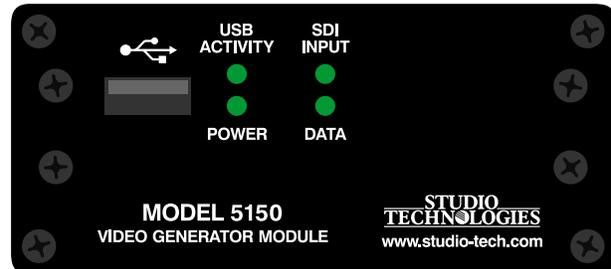The **Data** LED lights to represent the number **4**

Figure 9. Detail of front panel showing how the LEDs display the MCU and FPGA firmware version numbers.

3. After another slight pause one of the LEDs will light briefly. This will indicate the major number of the FPGA's firmware version. The LED will stop lighting then another one of the four LED will light briefly to indicate the minor number of the FPGA's firmware version. The range of each is 1-4. A period (.) is inserted between the major and minor numbers.

    As an example, if the SDI Input LED lights twice this would indicate version 2.2 of the FPGA firmware.

4. After a final short pause the four LEDs will begin performing in their normal operating manner. The Power LED will light and remain lit. The USB Activity LED will only be active when a USB flash drive is inserted and file transfer activity is taking place. The SDI Input LED will light whenever a valid SDI signal is connected to either the coaxial (BNC) input or the optical input, depending on the module's capability and configuration setting. The Data LED will light whenever local data is received via the RS-485 data bus from a Studio Technologies' Model 5190 Remote Access Module.

SFP Module Flexibility

The Model 5150 was designed to allow an MSA-compliant SFP optical module to be installed at the factory. Optical modules are available with a range of input and output capabilities to meet the needs of various applications. For maximum flexibility the SFP mating connector and associated "cage" on the Model 5150's FPGA circuit board were implemented to meet the electrical and mechanical requirements of the MSA SFP standard. The MSA SFP standard was originally developed for use with optical data (Ethernet) modules. It has also become popular for use with SFP modules that support SMPTE-compliant SDI signals.

It's interesting to note that several companies offer non-optical SFP modules that support the MSA SFP standard as well. For example, Embrionix of Canada offers a wide range of specialized SFP modules. These include coaxial SDI input and output modules that use DIN 1.0/2.3 and HD-BNC connectors. In addition, they offer SFP modules that provide an HDMI® output. Several of these modules have been installed and tested in Model 5150 modules at the factory and acceptable performance was confirmed. It's possible that special applications could benefit from the features provided by installing these non-optical SFP modules in a Model 5150. For further dialog about this topic please contact Studio Technologies technical support.

USB Port Capabilities

The USB port, accessible on the Model 5150's front panel, is provided for use in only a few specific tasks. While it implements a high-speed USB host interface, it is not intended for general-purpose use and does not support connection with mass-storage devices, personal computers, printers, etc. It is intended only for use with USB flash drives. These devices can contain image and firmware files that are intended for loading into the Model 5150. Details on these file-transfer functions can be found in other sections of this guide.

Specifications

SDI Compatibility, Supported Formats and Rates:

HD-SDI per SMPTE ST 292:2011:

720p: 50, 59.94, 60

1080i: 50, 59.94, 60

1080p: 23.98, 24, 25, 29.97, 30

1080psf: 23.98, 24, 25

3G-SDI Level A per SMPTE ST 424:2006 and ST 425:2011:

1080p: 50, 59.94, 60

SD-SDI per SMPTE® ST 259:2008:

Not supported

Coaxial (BNC) SDI Input and Output:

Type: unbalanced

Impedance: 75 ohms

Level: 800 mV p-p, nominal

Optical Input (optional):

Compliance: SMPTE ST 297:2006 (as applicable)

Fiber Type: single mode

Wavelengths Supported: 1250 to 1650 nm

Receive Sensitivity: –17 dBm, nominal @ 2.97 Gb/s

Maximum Input Power: –3 dBm, nominal

Optical Output (optional):

Compliance: SMPTE ST 297:2006 (as applicable)

Fiber Type: single mode

Wavelength: 1310 nm (FP laser) or CWDM (DFB laser), as per order

Launch Power: –3 dBm, nominal

Typical Fiber Interconnect Length: 10 km minimum

Remote Control Data Interface: RS-485 115.2 Kb/s, 8-1-N; compatible with Studio Technologies' Model 5190 Remote Access Module

Connectors:

Coaxial SDI Input and Output: BNC, 3G-SDI optimized, gold plating on center pin, per IEC 61169-8 Annex A

Optical Module: MSA-compliant SFP

DC Input/Data: 1, 4-position male header. Refer to Appendix B for mating connector details.

Power Requirement: 12 volts DC nominal, 400 mA max; acceptable range 10-18 volts DC, 480 mA max at 10 volts

Dimensions (Overall):

3.75 inches wide (9.5 cm)
1.69 inches high (4.3 cm)
2.30 inches deep (5.8 cm)

Mounting: requires custom implementation; no mounting method provided. Refer to Appendix C for details.

Weight: 0.2 pounds (91 g)

Specifications and information contained in this User Guide subject to change without notice.

Appendix A–Model 5150 Versions

The following list describes the available Model 5150 versions along with their respective order codes. List is current as of the publication date of this guide.

| Version	Order Code	Figure
Model 5150 Video Generator Module	M5150	A
Model 5150 Video Generator Module with Optical Output (1310 nm)	M5150-01	B
Model 5150 Video Generator Module with Optical Input/Output (1310 nm)	M5150-02	C
Model 5150 Video Generator Module with CWDM Optical Output	M5150-03X*	B
Model 5150 Video Generator/ Module with Optical Input/CWDM Output	M5150-04X*	C

For order codes -03X and -04X, X = the standard CWDM wavelength letter code, e.g., L=1490 nm.
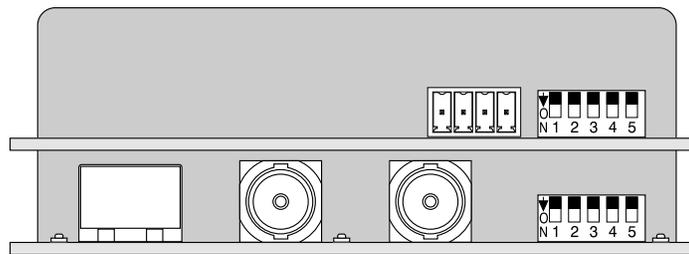
Figure A (No SFP)
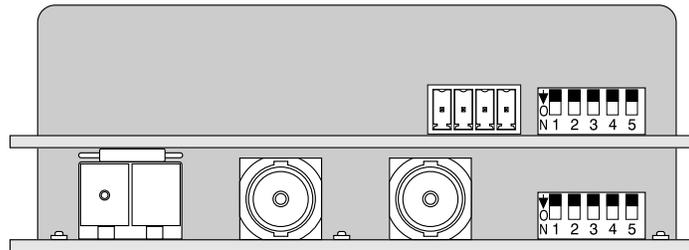
Figure B (Optical-Output-Only SFP)
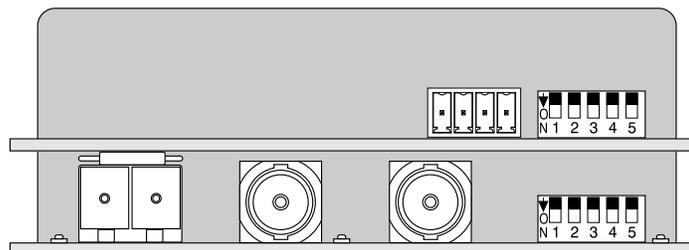
Figure C (Transceiver SFP)

Appendix B–DC Input/Data Interconnection Details

The required mating receptacle is from the TE Connectivity (formerly AMP) MTA-100 series of IDC (insulation displacement) connectors. This series was selected because of its low-cost and wide range of offerings. Separate connectors are offered for compatibility with 22, 24, 26, and 28 AWG (American Wire Gauge) insulated wire. The connector color indicates its AWG-compatibility. Unfortunately, with flexibility can come some confusion. The MTA-100 offers a number of different connectors that will work with the DC input/data header. Before obtaining receptacles it's important to determine two things: wire gauge and wiring arrangement. For this application 22 AWG is recommended.

DC Input/Data

• For 22 AWG wire this receptacle (red in color) is recommended:

TE Connectivity (AMP) 3-643813-4, closed-end type

Digi-Key part number A31108-ND

Mouser part number 571-3-643813-4

TE Connectivity (AMP) 3-644540-4, feed-through type

Digi-Key part number A31122-ND

Mouser part number 571-3-644540-4

Tools for Connecting Wires to the Mating Receptacles

For applications where just a few Model 5100-Series modules are going to be installed a manual IDC termination tool is recommended. While requiring a steady hand to achieve reliable wire connections to the mating receptacles, the price, at less than US$40, is fairly reasonable:

• "T Handle" termination hand tool:

TE Connectivity (AMP) 59803-1

Digi-Key part number A9982-ND

Mouser part number 571-598031

Appendix B–Interconnection Details, continued

Tools for Connecting Wires to the Mating Receptacles, continued

For applications where a larger number of Model 5100-Series modules are going to be installed it's worth considering a semi-automatic termination tool. The recommended tool consists of a handle assembly and crimp die for MTA-100 receptacles. The total price for both, approximately US$300 as of this writing, is steep but the performance that this tool assembly provides is excellent. We feel that the time savings and reliability of the connections may warrant the price when many terminations are going to be made:

• Handle Tool, Pistol Grip:

  TE Connectivity (AMP) 58074-1

   Digi-Key part number A2031-ND

   Mouser part number 571-580741

• Crimp Head Die Assembly for MTA-100 Receptacles:

  TE Connectivity (AMP) 58246-1

   *Digi-Key part number A1998-ND*

   Mouser part number 571-58246-1

Header on the Model 5150 Printed Circuit Board

The actual part number of the header connector that is soldered into the Model 5150's printed circuit board is provided in this section. But do not order this part number with the intent of interconnecting signals with the Model 5150! We are providing this detail only so that interested technical personnel can have the full background on the Model 5150's interconnect system. The appropriate mating receptacle is detailed in a previous section of this Appendix.

• DC Input/Data:
  TE Connectivity (AMP) 2-644486-4 **(DO NOT ORDER THIS NUMBER!)**

Appendix C–Model 5150 Front Panel and Printed Circuit Board (PCB) Dimensions

**STUDIO TECHNOLOGIES, INC.
MODEL 5100-SERIES SINGLE-WIDTH FRONT PANEL
AND PRINTED CIRCUIT BOARD DIMENSIONS
(DIMENSIONS SHOWN IN INCHES)
(AS OF JUNE 2013, APPLIES TO
MODELS 5110, 5120, 5121, 5130, 5132, 5134, 5150, 5152, 5162, 5180, AND 5190)**
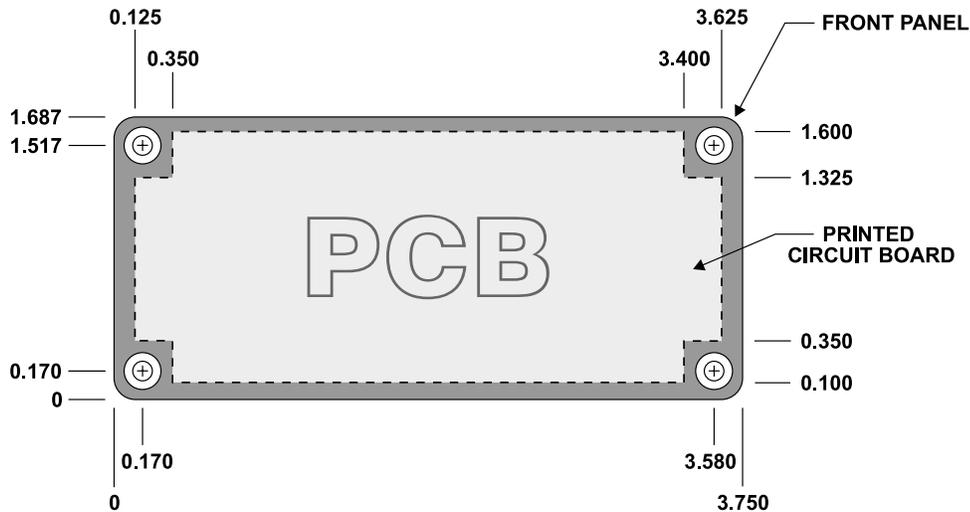
NOTES:

1) OPENING MUST BE MADE IN CUSTOM-MOUNTING ARRANGEMENT SO THAT PCB IS ALLOWED TO FREELY PASS THROUGH.

2) FRONT-PANEL MOUNTING LOCATIONS DIMENSIONED FOR #4 COUNTERSUNK SCREWS (4 PLACES).
   UNDERCUT FLAT-HEAD MACHINE SCREWS RECOMMENDED.

3) RECOMMENDED MOUNTING-HOLE LOCATIONS SHOULD BE DRILLED AND TAPPED FOR 4-40 SCREW THREADS (4 PLACES).

**WARNING:
THIS DRAWING SHOWS THE DIMENSIONS OF THE PRINTED CIRCUIT BOARD.
PANEL OPENING MUST BE MADE LARGER TO ALLOW PCB TO PASS THROUGH!
CONTACT FACTORY IF YOU HAVE QUESTIONS.**