AXSUN OCT SWEPT SOURCE ENGINE OPERATORS' MANUAL

Part No	
AXP50124	OEM version
AXP50125	Desktop version

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NOTICES:

This OCT Swept Source Engine is covered by a limited warranty. The warranty is detailed in the warranty section of this manual. The user may be required to perform routine maintenance as described herein on a periodic basis to keep the warranty in effect.

All information in this manual is subject to change without notice and does not represent a commitment on the part of Axsun Technologies, Inc.

The instrumentation in the system described herein is covered by the following patents: U.S. Patent Numbers: 6,768,756; 6,704,150; 6,674,065; 6,628,407; 6,625,372; 6,608,711; 6,559,464; 6,525,880; 6,404,567; 6,385,382; 6,373,632; 6,341,039; 6,487,355; 6,690,864; 6,776, 538; 6,790,698; 6,808,276; 6,836,366; 7,124,928; 7,415,049; 7,420,738; additional patents pending.

All software provided by Axsun Technologies, Inc. is furnished under a license agreement as described on its package. The software may be used on a single system and only in accordance with the license agreement. The user may make one copy of the program CD for archival purposes.

Axsun is a trademark of Axsun Technologies, Inc. Other company names and product names mentioned herein may be the property of their respective owners.

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Warnings and Safety Precautions

The Axsun OCT Swept Source Engine is a CLASS 1 LASER, a CLASS 1M LASER, a Class 3R LASER, or a CLASS 3B LASER Product depending on the output power level and it operating wavelength range. For each laser, appropriate label shown below is affixed.

CLASS 3B LASER: Wavelength : 1060 nm, Power >14.7mW & ≤ 1010 mW

A Class 3B laser is hazardous if the eye is exposed directly, but diffuse reflections such as from paper or other matte surfaces are not harmful.

Power down unit, setting key switch to off prior to connecting or disconnecting the FC/APC connector to the optical port labeled Laser Aperture. If no fiber patch cord is connected to the optical port, install the beam stop supplied with the unit.

CLASS 3R LASER: Wavelength : 1060 nm, Power >5.7mW & ≤ 14.7 mW

This class of laser is considered safe if handled carefully, with restricted beam viewing.

Power down unit, setting key switch to off prior to connecting or disconnecting the FC/APC connector to the optical port labeled Laser Aperture. If no fiber patch cord is connected to the optical port, install the beam stop supplied with the unit.

CLASS 1M LASER: Wavelength : 1310 nm, Power >24mW & ≤ 49.5 mW

This class of laser is not capable of causing injuries under normal operation unless the laser beam is viewed with an optical instrument.

CLASS 1 LASER: Wavelength : 1310 nm, Power ≤ 24 mW

This class of laser is not capable of causing injuries under normal operating conditions.

Table below shows each Axsun OCT Swept Source Engine Laser product and its Laser Class.

Product(s)	Wavelength (nm)	Average Power (mW)	Divergence (radians)	Laser Class	Min MPE (W/m^2)	NOHD (cm)
AXP50124-1 AXP50124-3	980-1100	≤ 2.8	>0.15	1	36.3	N/A
AXP50124-4 AXP50124-11		2.9 - ≤ 5.7		1M		N/A
AXP50124-13 AXP50124-14		5.8 - ≤ 14.7		3R		10-13
AXP50125-1 AXP50125-3		14.8 - ≤ 1010		3B		13-133
AXP50124-6 AXP50124-8	1250-1360	≤ 24.0	>0.12	1	400	N/A
AXP50124-9 AXP50124-12		24.1 - ≤ 49.5		1M		N/A
AXP50116 AXP50125-4 AXP50125-6 AXP50125-7		49.6 - ≤ 125.0		3R		10-16

The warning and caution signs shown below are included in various locations throughout this manual. These signs provide the following information:

CAUTION: The information in a caution statement relates to a condition that could lead to laser exposure, damage to equipment and/or lead to invalid analytical results.

The following precautions should be followed to minimize the possibility of personal injury and/or damage to property:

1. Make certain that you are familiar with the contents of this manual before working on or with the instrument.
2. There are no user serviceable components inside the unit. The user should not remove the cover.
3. The source used in the unit provides energy in the infrared region of the spectrum. Under anticipated conditions of use, operators have no risk of eye damage. The unit's optical output should not be placed close to the eye.
4. The internal components of this unit are sensitive to electrostatic discharges (ESD). Electrostatic charges as high as 4000V readily accumulate on the human body and can discharge without detection. Qualified personnel must do all servicing. To prevent ESD damage, do not open or remove covers.
5. Run the laser only with a fiber patch cord attached. Otherwise there is a risk of damaging the fiber end face inside the unit. When not connected to a fiber patch cord, the dust cover for the output connector should be kept in place.

NOTE: If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

CAUTION

CAUTION: Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

CAUTION

CAUTION: Turn off the unit or stop laser output before making or breaking optical connections to prevent damage to the connections due to high power density in the fiber core.

When the product includes this mark on the Product Labeling it indicates that the product has been tested to the requirements of CAN/CSA-C22-2 No.61010-1, second edition, including Amendment 1, or a later version of the same standard incorporating the same level of testing requirements.

Warranty

A. Hardware

Axsun warrants from the date of invoice from Axsun or its appointed distributor, as the case may be, that hardware Products furnished hereunder will be of merchantable quality, free from defects in material, workmanship and design for a period of one (1) year for qualified hardware Products and for three (3) months for nonqualified hardware Products. Repaired or replacement Products provided under warranty are similarly warranted for a period of six months from the date of shipment to Customer or the remainder of the original warranty term, whichever is longer.

AXSUN GIVES OR MAKES NO WARRANTY, REPRESENTATIONS OR UNDERTAKING, EXPRESS OR IMPLIED, WITH RESPECT TO PROTOTYPES, WHICH ARE PROVIDED “AS IS."

B. Software and Firmware

Unless otherwise provided in a Axsun or third-party license agreement, Axsun warrants for a period of one year from the date of invoice from Axsun or its appointed distributor, as the case may be, that standard software or firmware Products furnished hereunder, when used with Axsun-specified hardware, will perform in accordance with published specifications prepared, approved, and issued by Axsun's headquarters. Axsun makes no representation or warranty, express or implied, that the operation of the software or firmware Products will be uninterrupted or error free, or that the functions contained therein will meet or satisfy the Customer's intended use or requirements. Software and firmware corrections are warranted for a period of three months from the date of shipment to Customer or the remainder of the original warranty term, whichever is longer.

EXCEPT AS EXPRESSLY PROVIDED HEREINABOVE, AXSUN MAKES NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO PRODUCTS. AXSUN DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR ANY PARTICULAR PURPOSE.

NOTE: Opening the enclosure will void the warranty. There are no user serviceable parts inside.

1 Introduction

1.1 Overview

The Axsun OCT (Optical Coherence Tomography) Swept Source Engine is based on AXSUN Technologies' optical integration platform and patented MEMS tunable optical filter. The Axsun swept source engine enables real time, high resolution OCT imaging at rapid speeds and low cost.

The engine is available as a bench top engine (Figure 1-1) and as an OEM engine which can be incorporated into a customer's system enclosure (Figure 1-2). While the general mode of operation of the two versions is identical, installation and some features are slightly different. Where appropriate, this manual will indicate the information for both versions of the engine. The OEM version can accommodate a data acquisition board with a Camera Link® interface. The data acquisition board is described in detail in Appendix 3.

Figure 1-1: The Axsun OCT Swept Source Engine – Benchtop Version

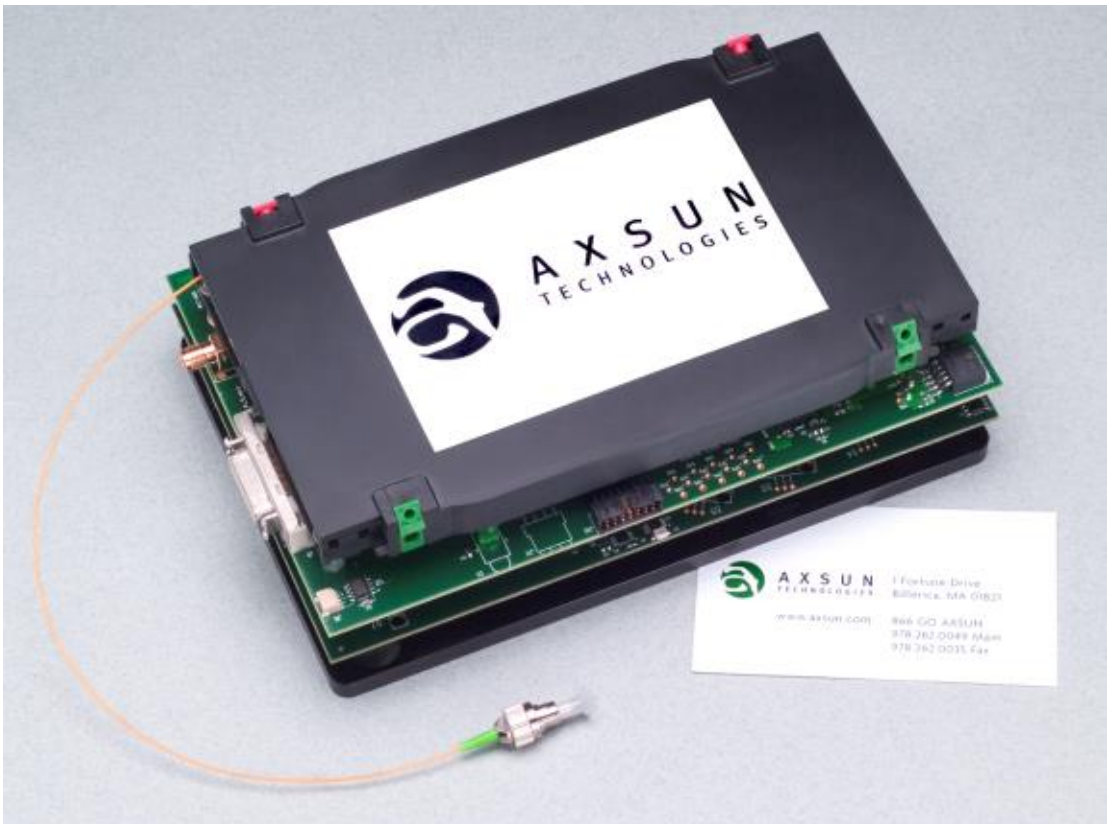


Figure 1-2: The Axsun OCT Swept Source Engine – OEM Version

Swept Source engines are available which cover the following wavelength ranges:

- Model SSOCT-1060 provides the wavelength range from 980-1100 nm.
- Model SSOCT-1310 provides the wavelength range from 1250-1360 nm.

Although the wavelength range and performance specifications of the engines differ, the operation of the engines is identical.

The engine provides the following features and benefits:

- Extremely high sweep speed and optical power
- Broad Tuning Bandwidth (> 100 nm)
- A small, low power, robust engine that can be embedded in an instrument
- A minimum infrastructure is needed; less optical/electrical wiring for other applications eliminates potential points of failure
- Low power consumption and high reliability

The basic system specifications of the engines are listed below (detailed system specifications are provided in Appendix 1 and Appendix 2):

- **SSOCT-1060**

  Wavelength Range: 980 nm - 1100 nm (10dB roll-off 100 nm within this range)
  Laser Average Output Power: 15 mW minimum
  Laser Sweep Speed: 10 - 100 kHz (the source operates at a fixed sweep rate within this range)
  Coherence Length: 10 mm minimum (6dB contrast round trip)

- **SSOCT-1310**

  Wavelength Range: 1250 nm - 1360 nm (10dB roll-off 100 nm within this range)
  Laser Output Power: 18 mW minimum
  Laser Sweep Speed: 10 - 50 kHz (the source operates at a fixed sweep rate within this range)
  Coherence Length: 12 mm minimum (6dB contrast round trip)

- **Common Specifications between the two engines (Bench Top version)**

  FC/APC panel connector
  Sweep trigger provided via SMA connector (0 to ~1.3V, 50 Ω)
  Includes Drive Electronics with key on-off switch for unit power and laser activation
  K-Clock Output: 0.2 - 0.8V, 50 Ω, (< 350MHz) via SMA connector

- **Common specifications between the two engines (OEM version)**

  FC/APC pigtail fiber optic output
  Sweep trigger provided via SATA connector (LVDS (1.0 to 1.4V))
  Includes Drive Electronics, controlled through USB port
  K-Clock Output: ECL (1.6 - 2.4V), 100 Ω, (< 350MHz) via SATA connector

1.2 Power Spectrum of the Engine

The time averaged spectral power output of a typical SSOCT-1060 engine is presented in Figure 1-3 and typical operating and scan parameters are given in Table 1-1. The corresponding data for a typical SSOCT-1310 engine is provided in Figure 1-4 and Table 1-2.

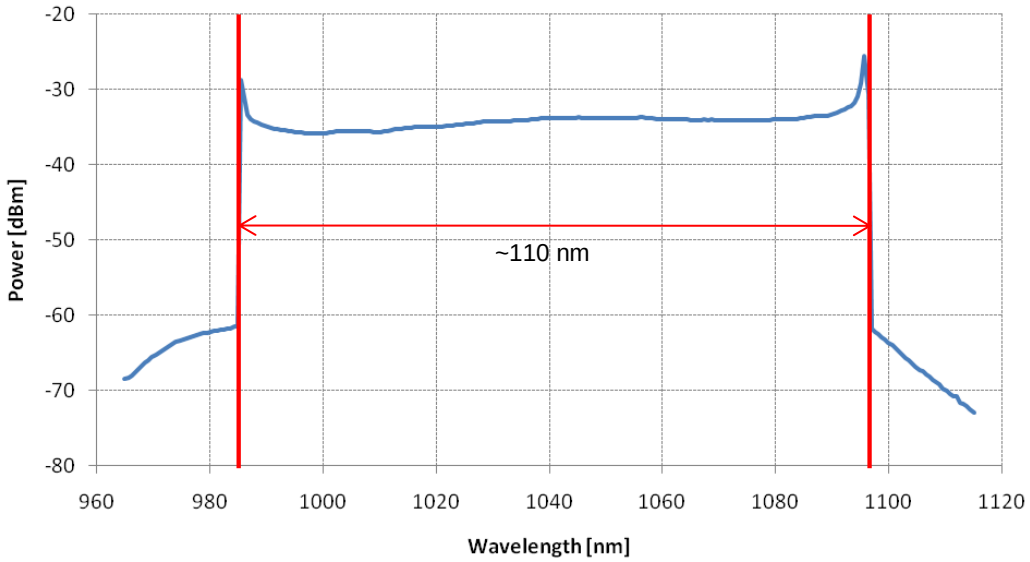


Figure 1-3: Time Averaged Power Output of a Typical SSOCT-1060 Engine

Table 1-1: Typical Scan Parameters for the SSOCT-1060 Engine

Parameter	Value
Wavelength Range	985.0-1095.0 nm
Scan Range in Air	3.7 mm
Sweep Frequency	100 kHz
Maximum Samples	1510
Selected Number of Samples	1376
Percent Bandwidth Used	91 %
Duty Cycle	45 %
Estimated Clock Frequency[1]	310 MHz

1 +/- 20 % Typical Variation

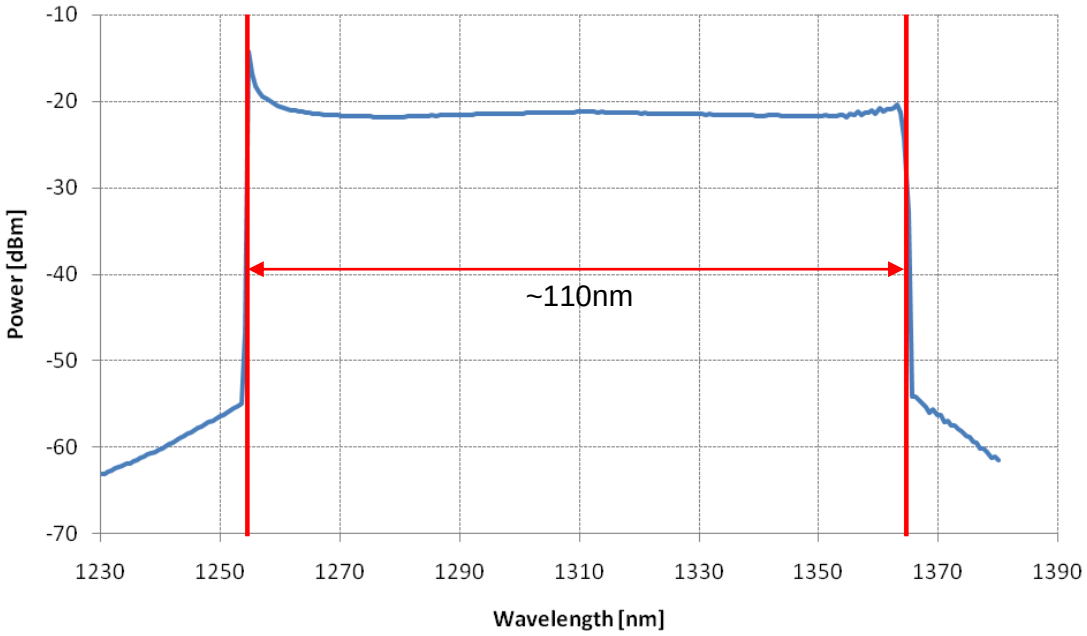


Figure 1-4: Time Averaged Power Output of a Typical SSOCT-1310 Engine

Table 1-2: Typical Scan Parameters for the SSOCT-1310 Engine

Parameter	Value
Wavelength Range	1260-1360
Scan Range in Air	5mm
Sweep Frequency	50kHz
Maximum Samples	1286
Selected Number of Samples	1170
Percent Bandwidth Used	91 %
Duty Cycle	45 %
Estimated Clock Frequency[1]	130 MHz

1 +/- 20 % Typical Variation

1.3 Clock and Spectral Power Typical Data

The **trigger**, **optical power**, **clock signal**, and **clock frequency** for a typical OCT-1060 engine is shown in Figure 1-5 and the corresponding information for a typical OCT-1310 engine is shown in Figure 1-6.

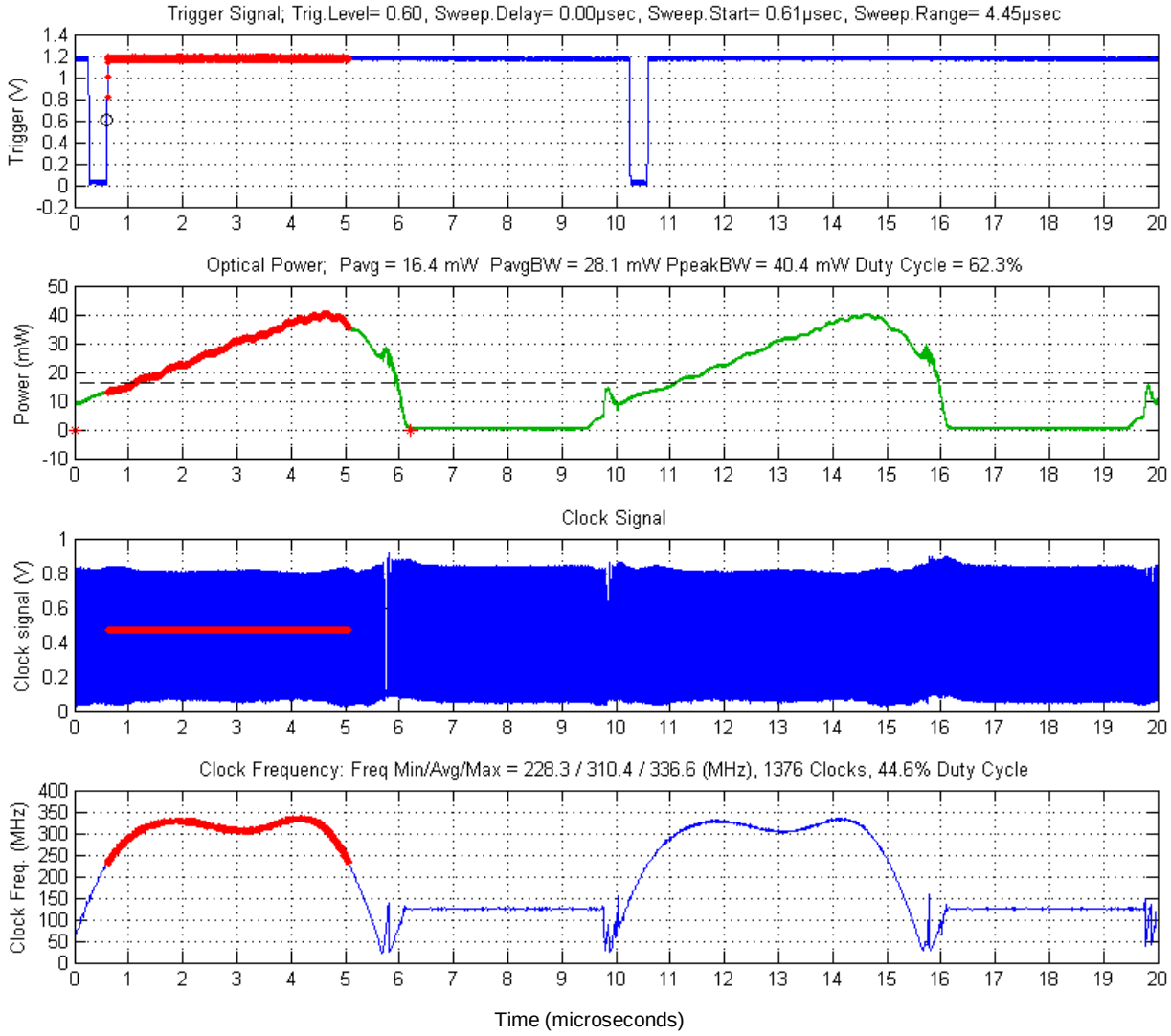


Figure 1-5: Typical Spectral Power and Clock Data for the SSOCT-1060 Engine

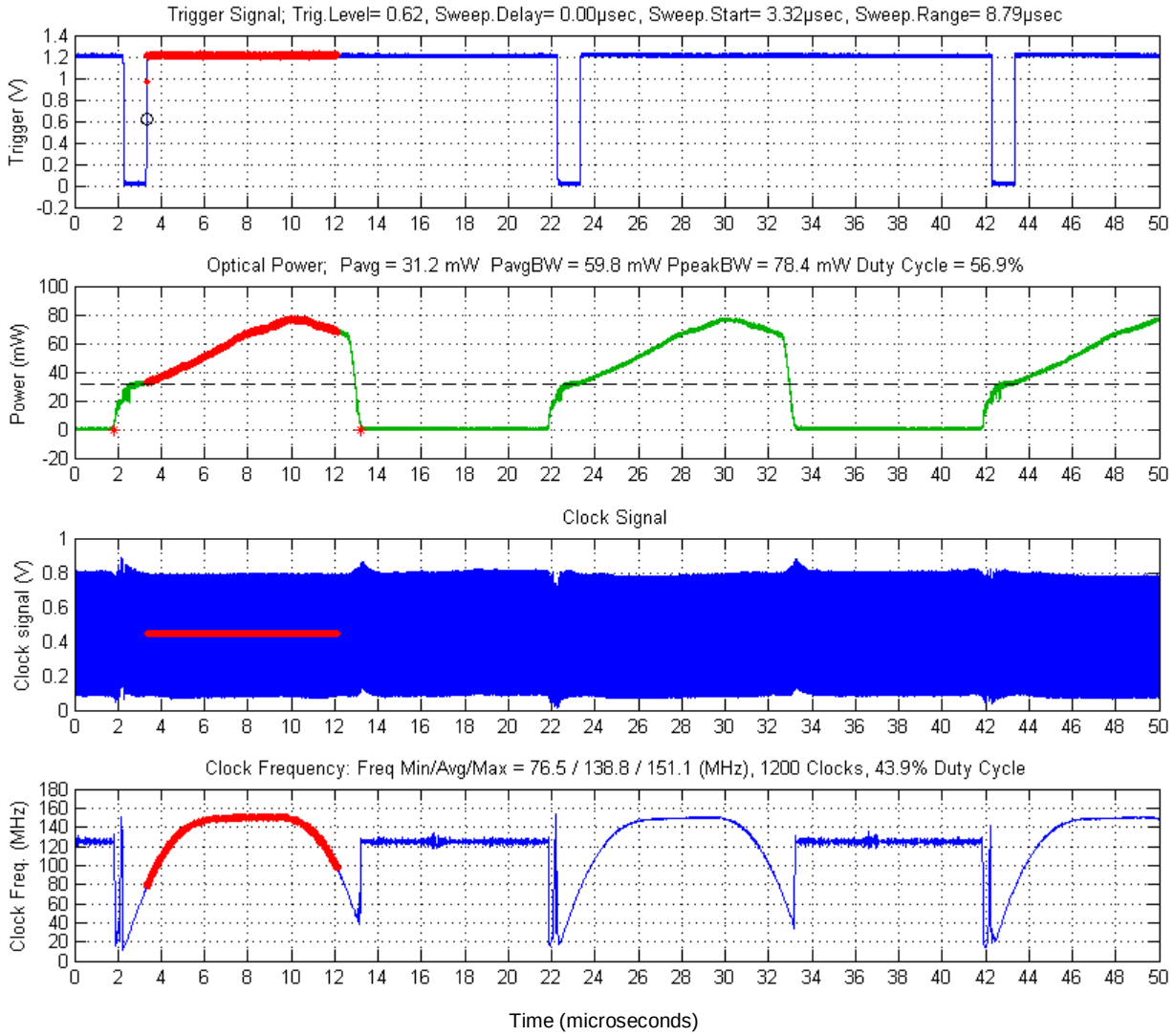


Figure 1-6: Typical Spectral Power and Clock Data for the SSOCT-1310 Engine

2 Installation

2.1 Receipt of the System

When the system arrives, inspect the packaging for external signs of damage. If there is any obvious physical damage, request that the carrier's agent be present when the unit is unpacked. It is recommended that you retain the shipping container so that it may be used for future shipment of the unit, if necessary.

Remove the engine from the package and verify that all parts indicated on the packing list (Benchtop system, Table 2-1; OEM system, Table 2-2) are present and are not damaged. If a component is damaged or missing, notify the carrier and Axsun Technologies (or your local representative) immediately and follow the shippers instructions for damage claims.

Table 2-1: Packing List - Benchtop System

Item	Part Number	Quantity
Benchtop Engine	AXP50125	1
Power Supply	AXS83605	1
USB cable	AXS83463-2	1
CD containing user manual and software GUI	AXP50128	1
Fiber Optic Cable	AXS83748 for 1060 engine AXS83749 for 1310 engine	1

Table 2-2: Packing List OEM System

Item	Part Number	Quantity
OEM Engine	AXP50124	1
Power Supply	AXS83605	1
USB cable	AXS81649	1
CD containing user manual and software GUI	AXP50128	1
Power supply adapter cable	AXA10987	1

2.2 Environmental Requirements

2.2.1 Electrical Requirements

The Benchtop system is provided with a 100-240 VAC external auto-switching power supply which supplies 12 V/3.3 A. The external power supply is plugged into the power socket on the rear panel of the system.

The OEM version requires a 12 V/3.3 A power supply, the same external power supply provided can be hooked up to the OEM Engine with an adapter cable that is provided.

2.2.2 Temperature/Humidity

The Benchtop system is designed to be operated at ambient temperatures (10-35ºC) and 10-90% relative humidity.

The OEM system should be maintained at the same temperature range as the benchtop system. If it is installed as a component in a system, take care that appropriate ventilation is provided in order to maintain the heatsink temperature at 50ºC max.

2.2.3 Space Requirements

The physical dimensions of the benchtop system are 278 x 156 x 94.5 mm (10.94 x 6.14 x 3.72”) and it weighs 3.5 lbs (1.6 kg).

The physical dimensions of the OEM unit are 178 x 114 x 54 mm (7.0 x 4.5 x 2.1”) and it weighs 1.3 lbs (0.6 kg).

2.2.4 Computer Requirements

Axsun provides an application program which can be used to obtain a broad range of diagnostic information regarding the operation of the engine. This application program requires a personal computer with the Windows® XP Operating System, a USB port and a CD drive.

2.3 Installation - Application Software

The application software provided on the CD is provided to allow the user to set and observe various operating parameters of the engine, and upload firmware or other files to the engine if needed. The software should be installed on the computer before the computer is interfaced to the engine.

To install the application software:

a) Place the CD in the drive and select **Setup** to present the *Welcome* dialog box (Figure 2-1).

Figure 2-1: Welcome Dialog Box

b) Select **Next** to present the *Select Installation Folder* dialog box (Figure 2-2). The *Disk Cost* button accesses a dialog box which indicates the amount of space on each disk in the computer. The program requires about 12 MB and it is recommended that you use the directory suggested by the dialog box.

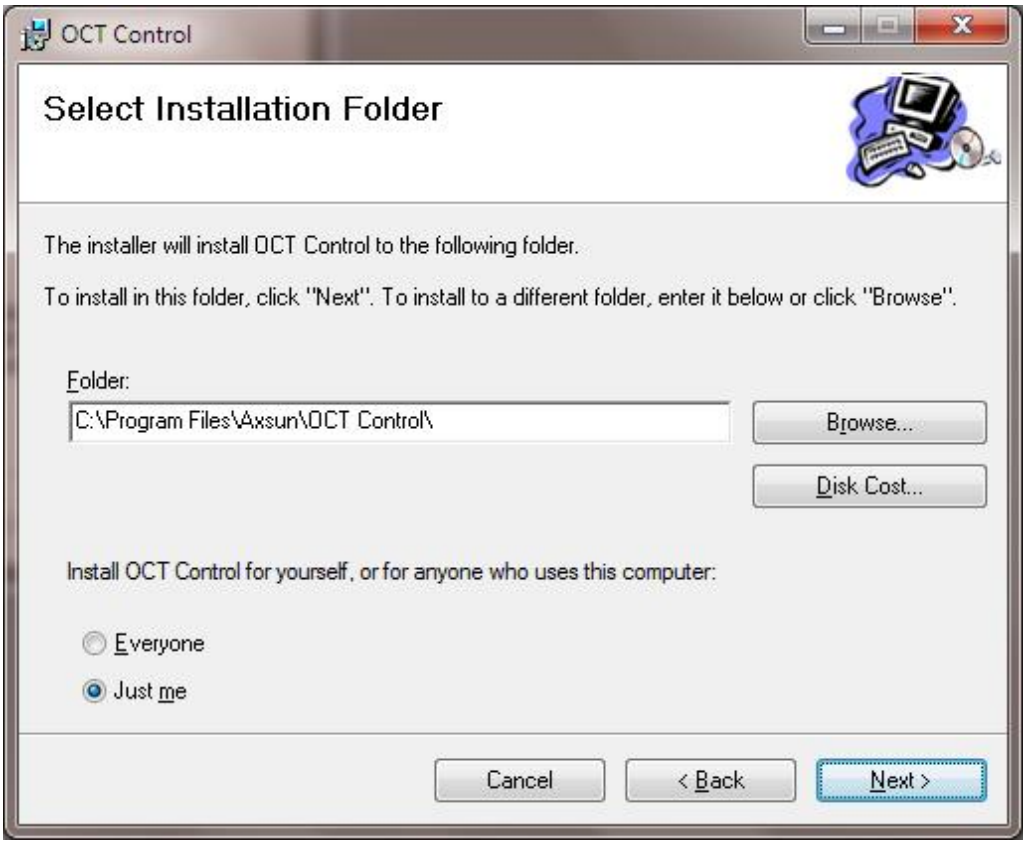


Figure 2-2: Select Installation Folder Dialog Box

c) Click **Next** to present the *Confirm Installation* dialog box (Figure 2-3).

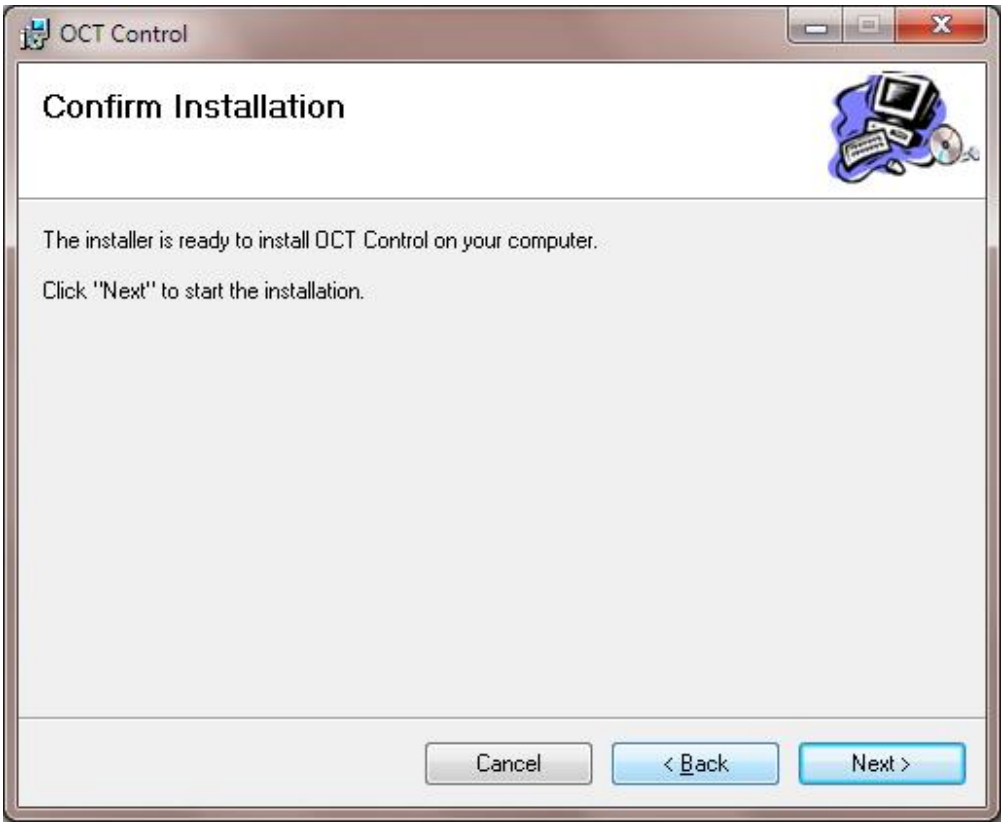


Figure 2-3: Confirm Installation Dialog Box

d) Press **Next** to initiate the installation. A dialog box with an installation progress bar will be presented to indicate the progress of the software (Figure 2-4).

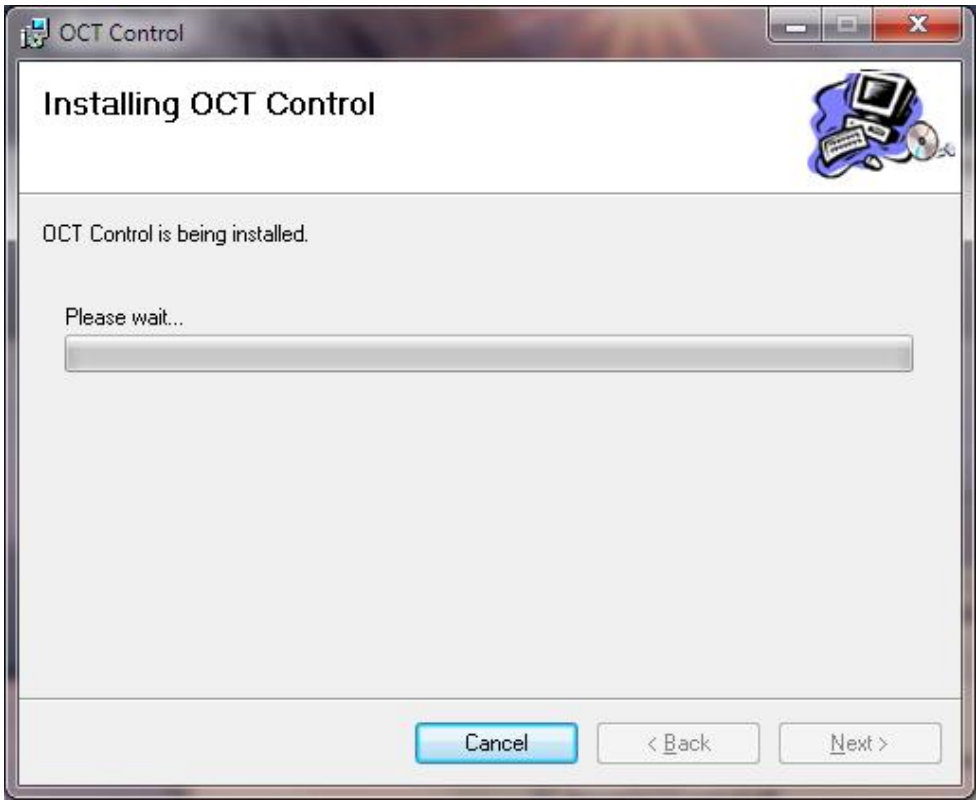


Figure 2-4: Installation Dialog Box

The computer may present a screen that says that the software is from an unknown publisher and asks the user to permit changes to be made to the computer. If this message is presented, press **Yes**.

Once the software is installed, click on the **OCT Host** icon on the *Start* menu to open the program (Figure 2-5). A detailed discussion of the window is presented in Chapter 3.

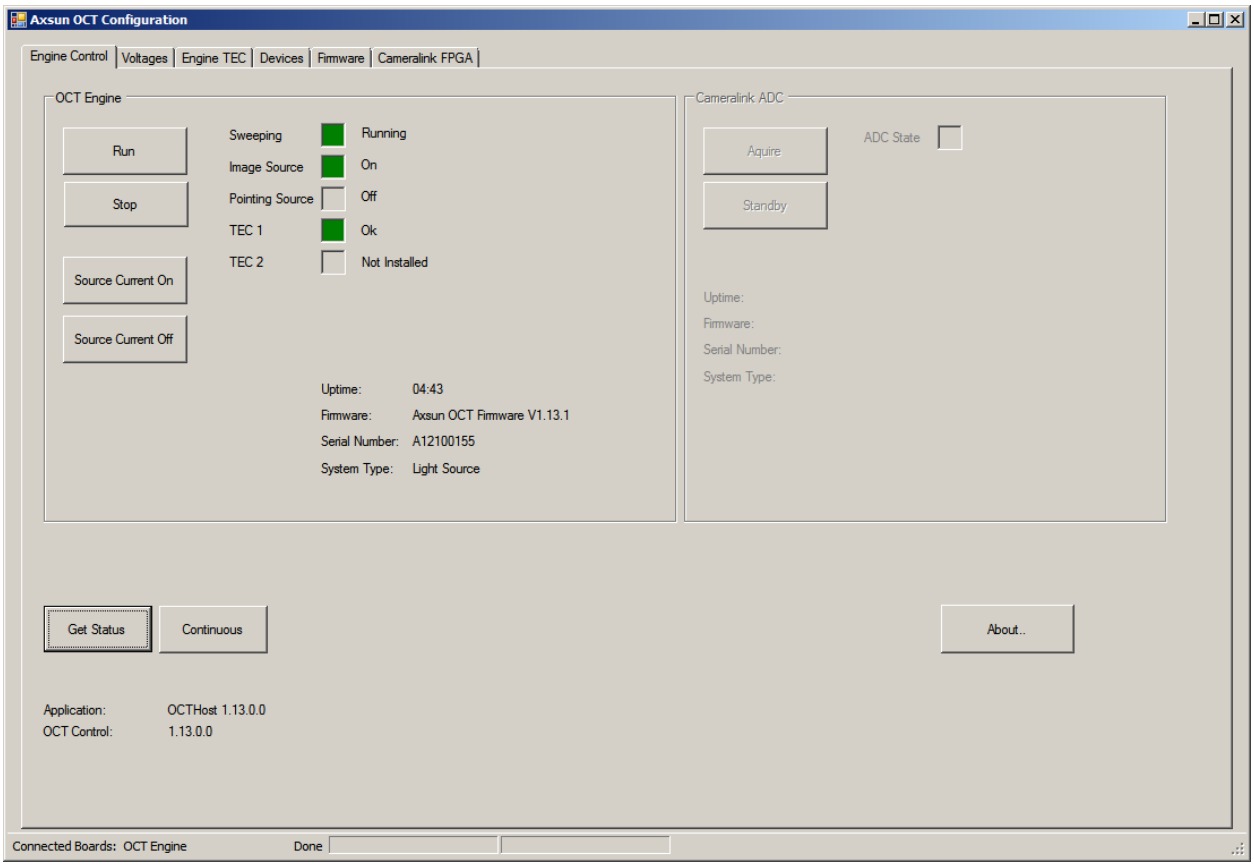


Figure 2-5: The Axsun OCT Configuration Window

2.4 Installing the Engine

2.4.1 Benchtop Unit

To install the benchtop unit:

a) Connect a fiber optic patch cord to the Optical output (Item 2, Figure 2-6) and to the desired external component.

b)

CAUTION: Fiber Optic Cables are fragile. If it is necessary to bend the cable to accommodate the experimental setup, take care that a moderate bend is employed (the minimum diameter should be at least 20 mm).

CAUTION: Do not run the laser without a fiber patch cord attached. Otherwise there is a risk of damaging the fiber end face inside the unit.

CAUTION: Note the potential for exposure to laser energy if the system is operated without a fiber optic patch cord attached.

Figure 2-6: Front Panel – Bench top Version

a) Connect the Sweep Trigger (item 5), and the Clock (item 6) to the appropriate device using an SMA – BNC cable or the appropriate 50 Ω impedance cable.

b) Connect the USB cable provided to the USB port on the rear panel (item Figure 2-7).

Figure 2-7: Rear Panel – Bench Top Version

c) Connect the USB Port on the rear panel to the personal computer.

d) Insert the key provided into the key power switch (Item 3 Figure 2-6).

e) Install the connector from the power supply to the 12 VDC port.

f) Turn the key power switch to the ON position to start the unit. The start sequence takes approximately 10 seconds. During the start sequence, the *Power* indicator on the front panel will blink and the unit will perform the start-up protocols and self test. After 10 seconds, swept spectrum optical energy will be emitted from the *Optical* output and the *Laser* indicator will be permanently lit.

2.4.2 Benchtop Unit Interlock pin out

Pin #	Function	Logic Type	Logic Level
1	Engine ON/OFF	CMOS TTL	1 = ON, 0 = OFF
2	Laser Current Interlock	CMOS TTL	H = Laser ON, L = Laser OFF
3	Optional Pointing Laser Interlock	CMOS TTL	H = PLaser ON, L = PLaser OFF
4	Not Used		
5	Not Used		
6	+3.3V	CMOS TTL	Jumper to Pin#1 Engine ON
7	+3.3V	CMOS TTL	Switch / Jumper to Pin#2 to enable Interlock
8	+3.3V	CMOS TTL	Switch / Jumper to Pin#3 to enable Interlock
9	Not Used		

If the interlock is tripped, the laser shuts off in less than 25µsec, requires the interlock condition to be corrected and the Engine RESET through Pin 1 or Power cycle.

2.5 Installation - OEM Unit

a) Install the fiber optic cable from the *Optical* output (Item 1, Figure 2-8) to the desired external component. The optical cable output can be on either side A or side B.

b) Connect the various cables as indicated in Figure 2-9 and Table 2-3.

CAUTION

CAUTION: Fiber Optic Cables are fragile. If it is necessary to bend the cable to accommodate the experimental setup, take care that a moderate bend is employed (the minimum diameter should be at least 20 mm).

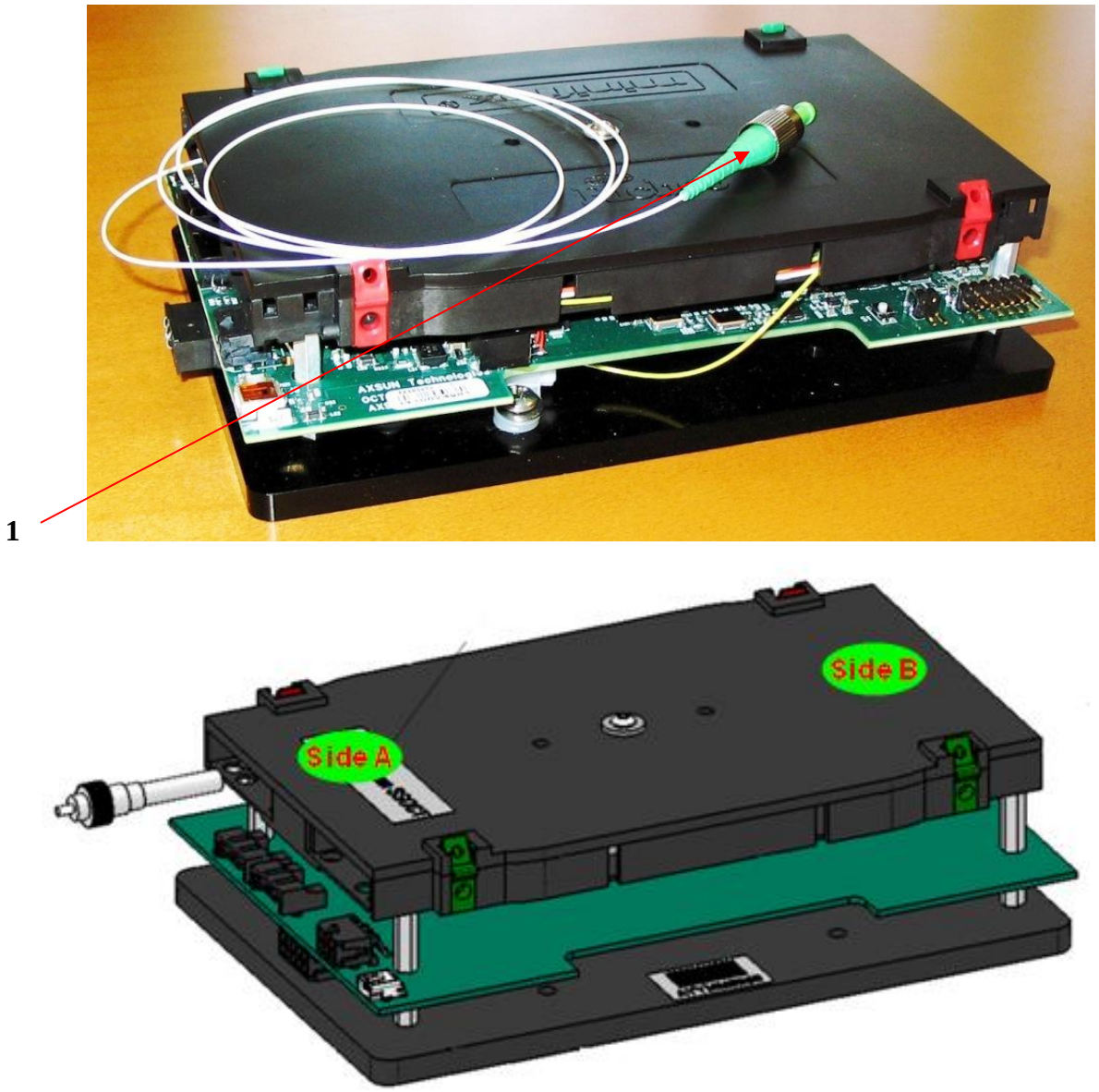


Figure 2-8: Installation of Laser Output Cable - OEM Unit

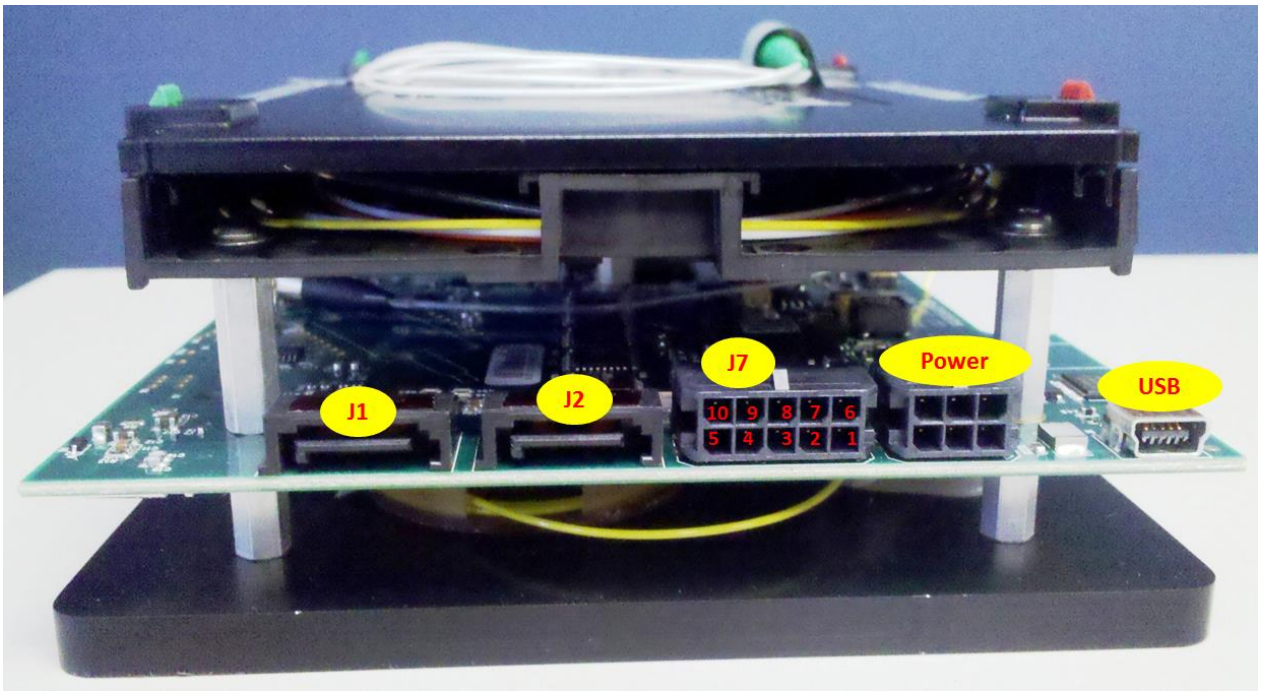


Figure 2-9: Connector positions - OEM Unit

Function	Connector Number	Connector Type/PN
Optional Balanced Receiver	Connector J1	SATA Molex 0470801020
Sweep Trigger (LVDS)	Connector J2	SATA Molex 0470801020
Optional Clock (ECL), 1.6-2.4V	Connector J2	SATA Molex 0470801020
OCT Engine ON/OFF	Connector J7, Pin 1	Molex 43045-1008
Laser Interlock	Connector J7, Pin 2	Molex 43045-1008
Optional Pointer Interlock	Connector J7, Pin 3	Molex 43045-1008
Power Monitor	Connector J7, Pin 4	Molex 43045-1008
Laser current on signal	Connector J7, Pin 5	Molex 43045-1008
Power Supply	Connector Power	Molex 43045-0608
USB MiniB	Connector USB	USB MiniB Molex 54819-0572

Table 2-3: Connector Functions

The wiring of cables to external devices is shown in Figure 2-10.

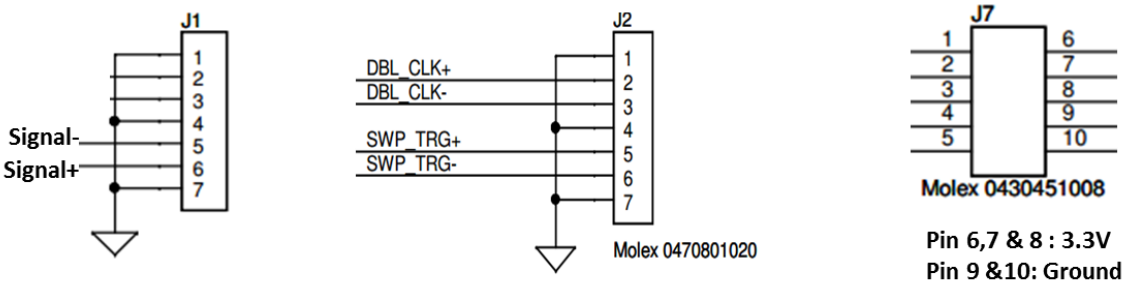


Figure 2-10: Wiring to External Devices

2.5.1 Details of the Electrical Connectors

a) Connector 1 and Connector 2

Connector 1 (SATA Molex 0470801020) is used for the Optional Balanced Receiver and connector 2 can be used for the Sweep Trigger or Optional K-Clock. The connector mates with MOLEX part numbers 67489, 88750-5310, 88750-5318, 88750-5410 and 88750-5418.

Dimensional Information for this connector is shown in Figure 2-11 and pinouts are shown in Figure 2-12.

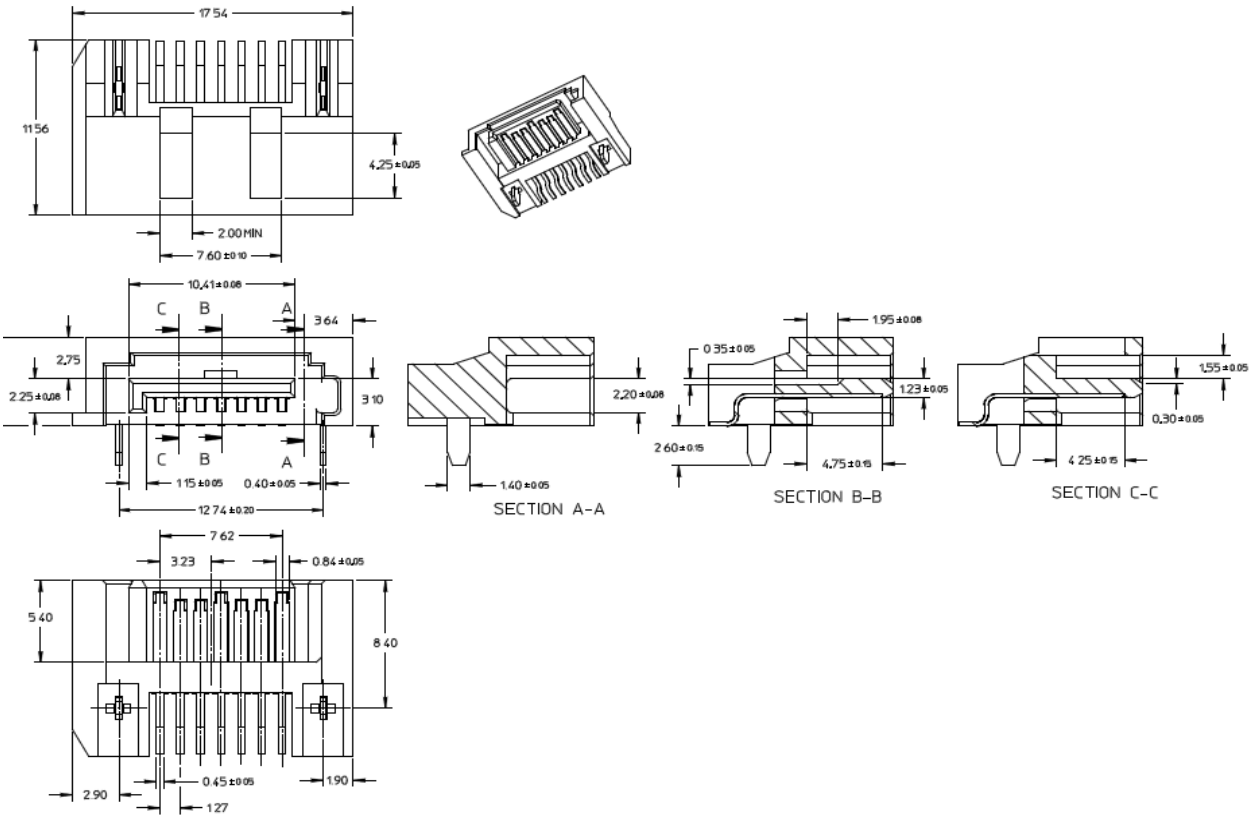


Figure 2-11: Dimensional Information - Connectors 1 and 2

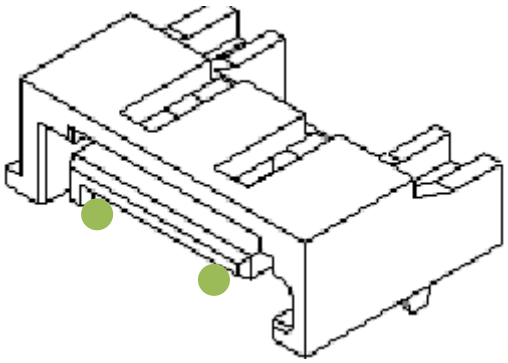
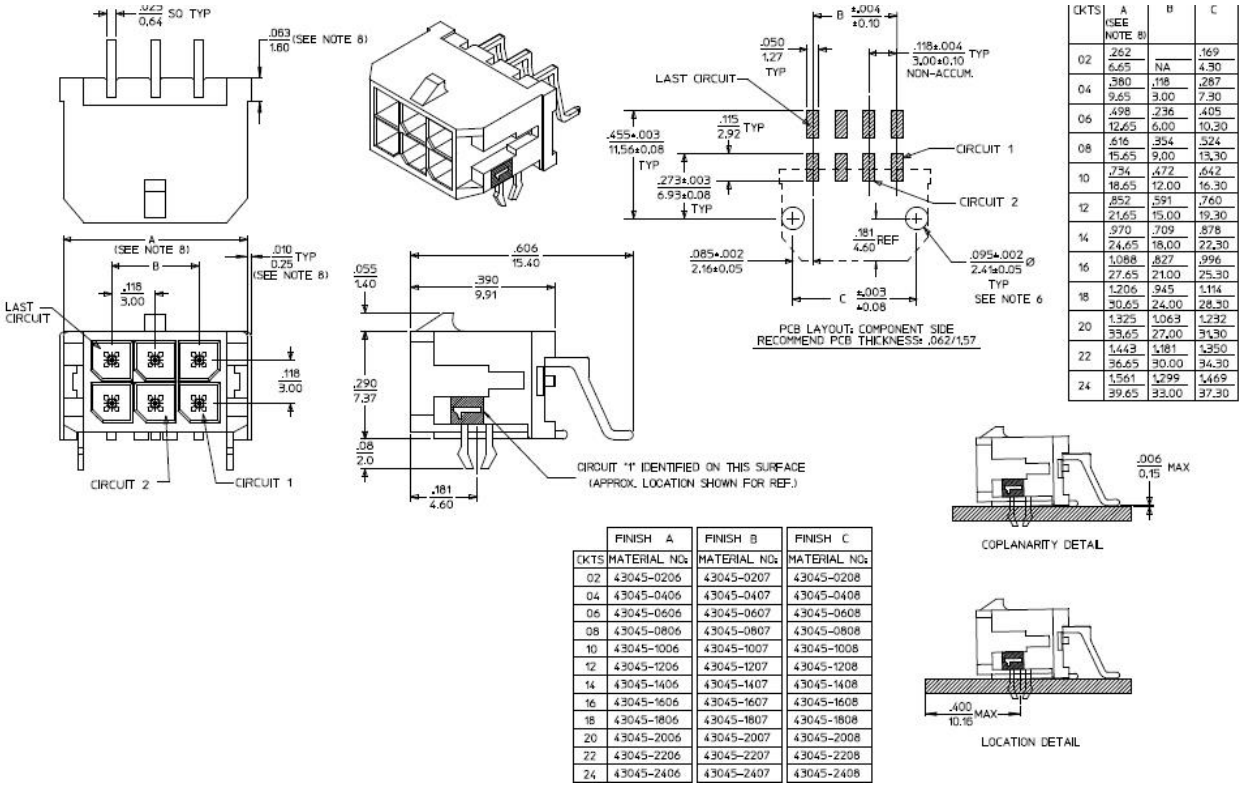


Figure 2-12: Pinouts - Connector 1 and 2

b) Connector 3 and Connector 4

Connector 3 (Molex 43045-1008) can be used for the OCT Engine ON/OFF, Laser Interlock and Optional Aiming Laser and Connector 4 (Molex 43045-0608) is used for the power supply. The connector mates with MOLEX part number 43025. Dimensional Information for these connectors is shown in Figure 2-13 and pinouts are shown in Figure 2-14.



CKTS	A (SEE NOTE 8)	B	C
02	.262 / 6.65	NA	.169 / 4.30
04	.380 / 9.65	.118 / 3.00	.287 / 7.30
06	.498 / 12.65	.236 / 6.00	.405 / 10.30
08	.616 / 15.65	.354 / 9.00	.524 / 13.30
10	.734 / 18.65	.472 / 12.00	.642 / 16.30
12	.852 / 21.65	.591 / 15.00	.760 / 19.30
14	.970 / 24.65	.709 / 18.00	.878 / 22.30
16	1.088 / 27.65	.827 / 21.00	.996 / 25.30
18	1.206 / 30.65	.945 / 24.00	1.114 / 28.30
20	1.325 / 33.65	1.063 / 27.00	1.232 / 31.30
22	1.443 / 36.65	1.181 / 30.00	1.350 / 34.30
24	1.561 / 39.65	1.299 / 33.00	1.469 / 37.30

CKTS	FINISH A MATERIAL NO:	FINISH B MATERIAL NO:	FINISH C MATERIAL NO:
02	43045-0206	43045-0207	43045-0208
04	43045-0406	43045-0407	43045-0408
06	43045-0606	43045-0607	43045-0608
08	43045-0806	43045-0807	43045-0808
10	43045-1006	43045-1007	43045-1008
12	43045-1206	43045-1207	43045-1208
14	43045-1406	43045-1407	43045-1408
16	43045-1606	43045-1607	43045-1608
18	43045-1806	43045-1807	43045-1808
20	43045-2006	43045-2007	43045-2008
22	43045-2206	43045-2207	43045-2208
24	43045-2406	43045-2407	43045-2408

Figure 2-13: Dimensional Information - Connector 3 and 4

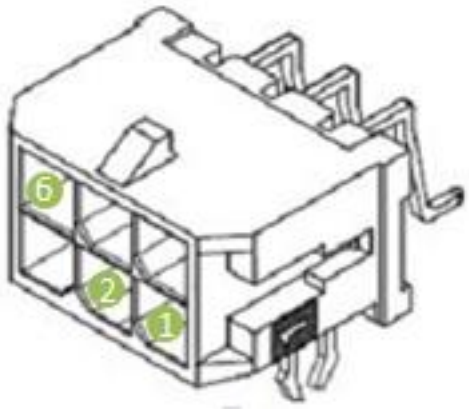


Figure 2-14: Pinouts - Connector 3 and 4

c) Connector 5

Connector 5 (USB MiniB Molex 54819-0572) is used for the USB signal bus. The connector mates with MOLEX part numbers 59204-9401 and 59205-3301. Dimensional Information for this connector is shown in Figure 2-15 and pinouts are shown in Figure 2-16.

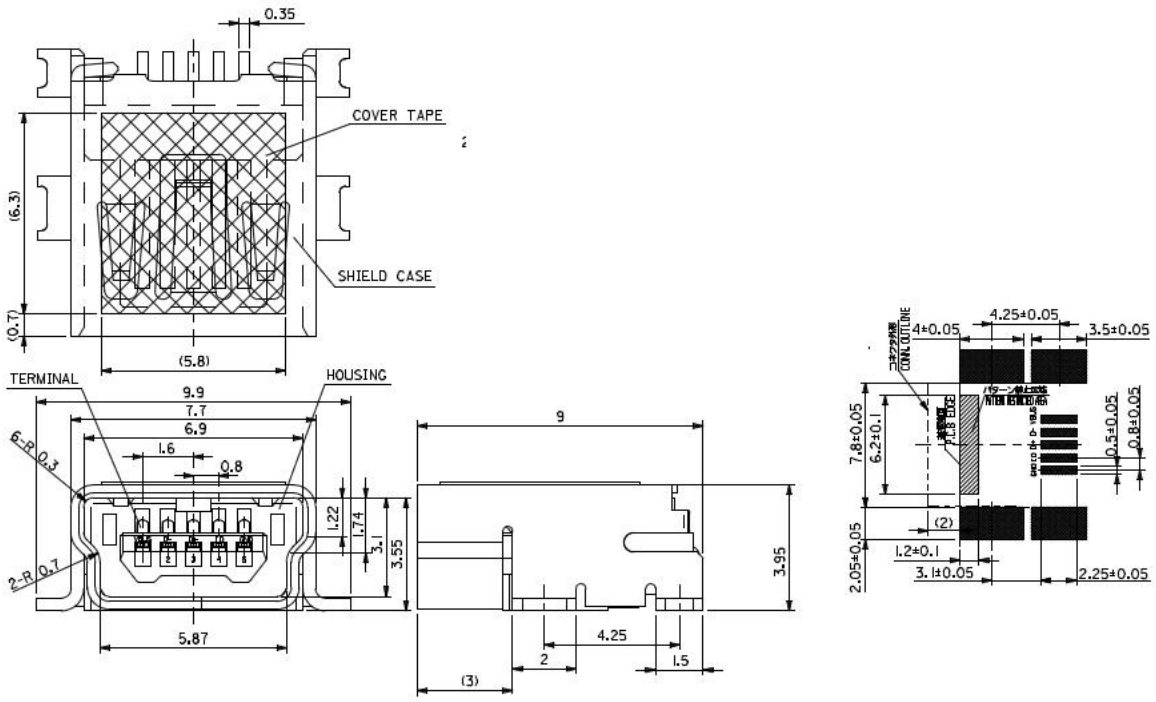


Figure 2-15: Dimensional Information - Connector 5

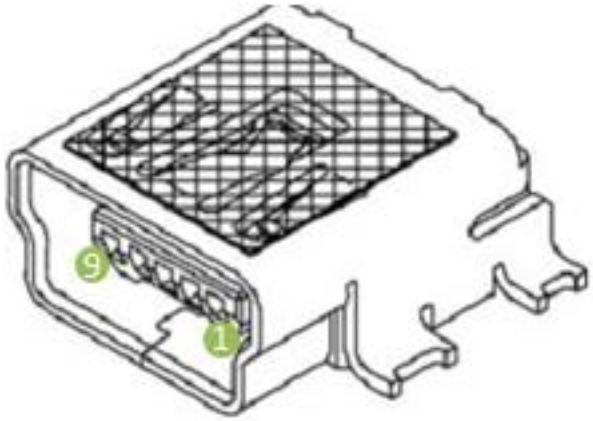


Figure 2-16: Pinouts - Connector 5

3 OCT Control Application Software

3.1 Introduction

The Axsun OCT Swept Source Engine is controlled by a user interaction program that is described in this chapter. The program includes eight tabs.

Note: The graphical user interface described below is employed with the engine as well as the engine with the data acquisition board. If the system does not include the data acquisition board, the FPGA settings tab (Section 3.9) and portions of other tabs will be grayed out. This section describes the program for an engine that does not include the data acquisition board. Appendix 3 describes the program for systems that include a data acquisition board.

3.2 Device Control Tab

When the software is powered up, the *Device Control* tab of the *Axsun OCT Configuration* window is presented (Figure 3-1) and the engine will communicate with the computer. Figure 3-1 is the main operating tab which controls normal operation of the system and indicates system status.

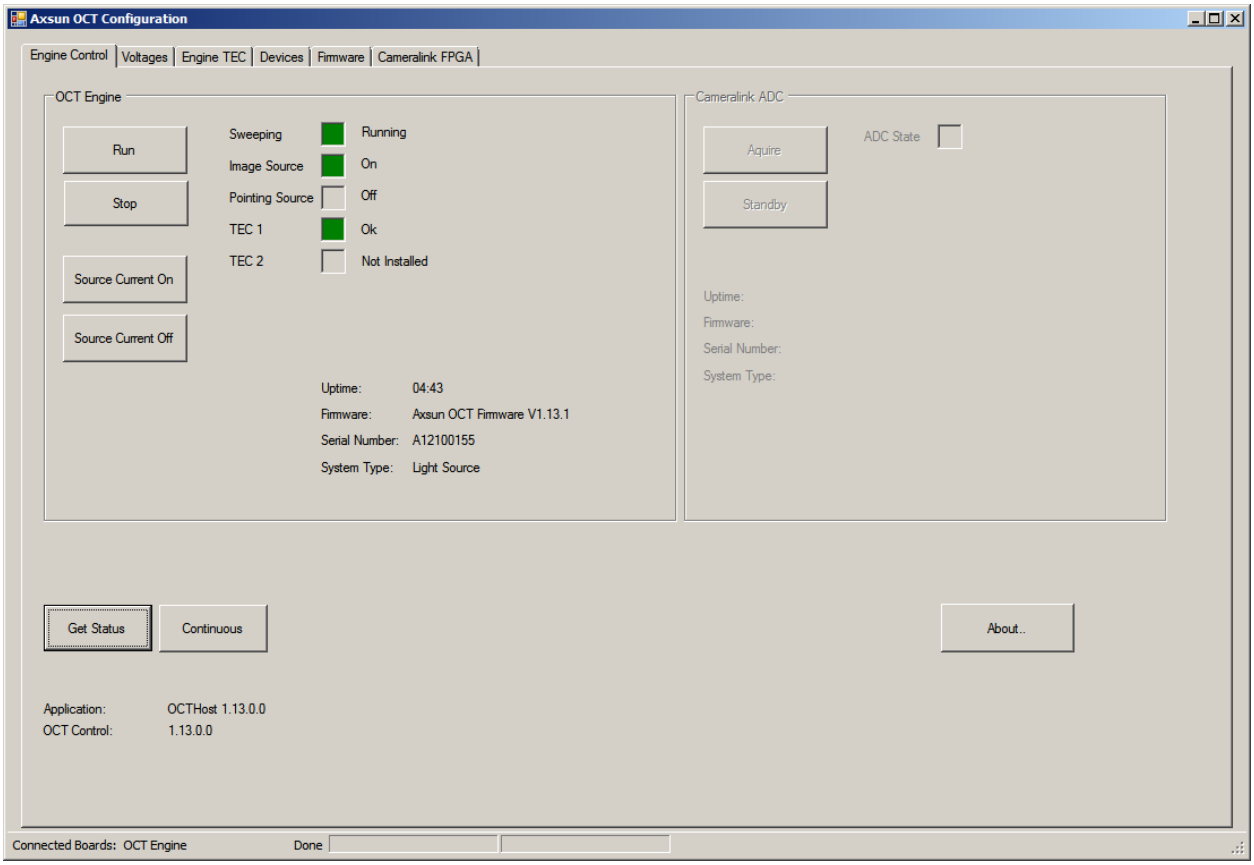


Figure 3-1: Device Control Tab

OCT Engine Section (upper left region of screen):

- The *Run* button is used to start sweeping of the laser
- The *Stop* button stops the sweeping of the laser

The *Sweeping*, *Image Laser*, *Pointing Laser* and *TEC* boxes indicate the status of various devices. The green color indicates that the device is on and operating properly. If the device is not operating, the box will be gray. During start-up, the *TEC* box will be orange and the message *TEC Waiting for Ready* will be presented.

- Sweeping - Indicates if the laser wavelength is sweeping
- Image Laser - Indicates if the main image laser is on or off
- Pointing Laser - Indicates if the pointing laser is on or off
- TEC - Indicates the TEC cooler status.

The *Application* field indicates the software version of the host application and the *OCT Control* field indicates the software version of the OCT control (this is the DLL that communicates with the OCT system).

The *Get Status* button will update the status of the system and the *Continuous* button will lead to updating of the status of the system every 500 msec. To stop the continuous updating, press *Continuous* again.

The *OCT ADC* region describes operation of the optional data acquisition board and is discussed in Appendix 3.

3.3 Voltages Tab

The *Voltages* tab (Figure 3-3) contains status information on various operating parameters of the Control Electronics, Laser and Tunable Filter in the Swept Source Engine. This tab also and allows for setting of the K-clock delay.

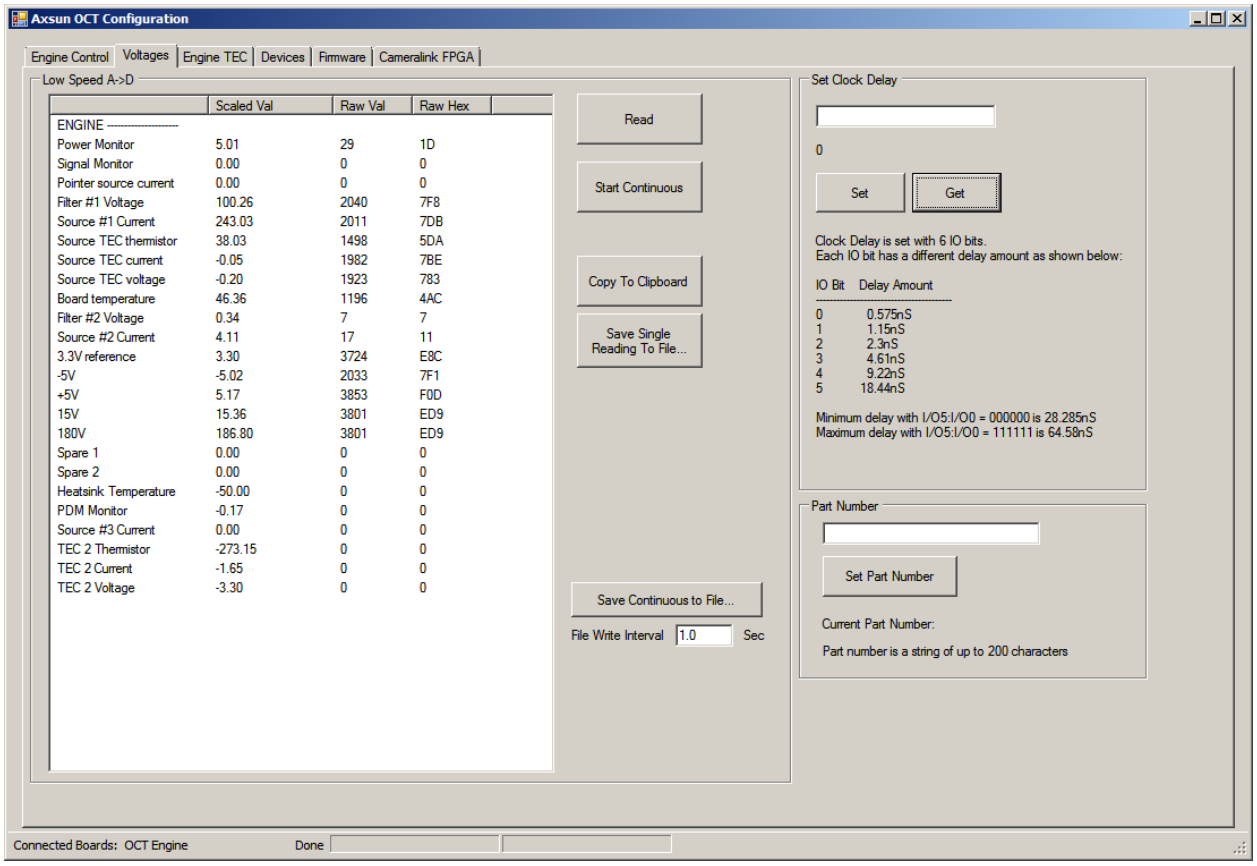


Figure 3-2: The Voltages Tab

3.3.1 Low Speed A->D Table

The Low Speed A->D table lists the Scaled values, Raw values and Raw Hex values for a broad range of operating parameters which are used for troubleshooting purposes.

The *Read* button obtains the current setting for each parameter from the engine.

The *Start Continuous* button allows for display of the current readings every 0.5 sec. To stop continuous display of the parameters, press the button again.

The *Copy to Clipboard* button sends the present settings to the clipboard for use in another program

The *Save Single Reading to File* button will cause the present values to be saved in a .txt file

The *Save Continuous to File* button will cause the data to be saved to the file at the interval indicated in the *File Write Interval* field.

3.3.2 Set Clock Delay

The *Set Clock Delay* section of this tab is used to indicate, and adjust the delay for the K-clock to match the length of fiber used in the OCT system. The minimum delay is 28.3 nsec (electrical delay from engine) and this delay can be adjusted to 64.6 nsec in 0.575 nsec intervals.

Selection of the appropriate delay is dependent on the length of fiber used between the balanced receiver and the Engine. A detailed drawing of the system configuration is shown in Figure 3-4.

The clock delay is set between the minimum delay, 28.285 nsec and the maximum delay, 64.58 nsec in 0.575 nsec intervals (from 0 to 63 in the *Set Clock Delay* window).

For example,

In the window → Clock delay in ns

0 → 28.3 ns

10 → 34.0 ns

63 → 64.6 ns

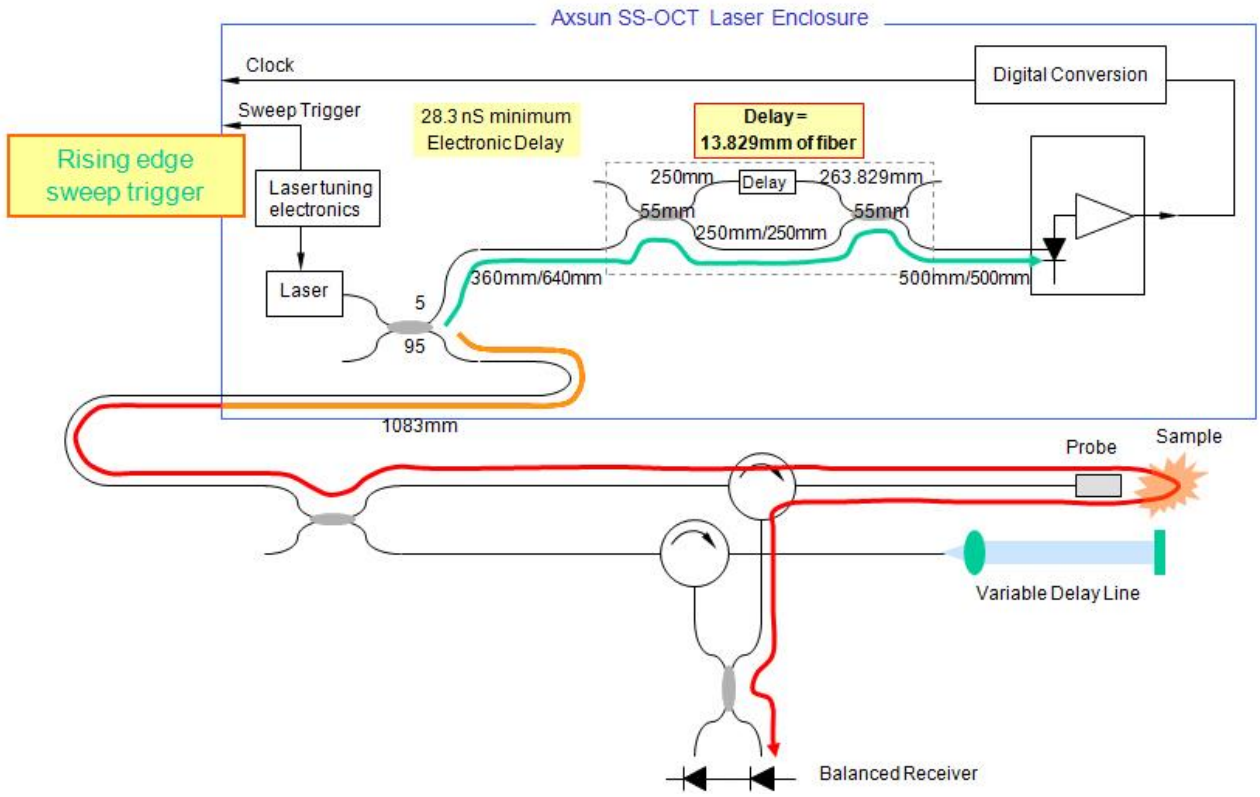


Figure 3-3: Determining the Delay Time

The orange and red path should be approximately matched to the green path plus the electronic delay to achieve transform limited signal reconstruction. The *Set* button is used to send the delay time to the engine and the *Get* button is used to retrieve the present delay time. The time is based on the distance and speed of light.

For the diagram above, if the red portion of the fiber in your system is 12 meters long:

- The Green path = 360 + 640 + 55 + 250 + 250 + 55 + 500 + 500 = 2610 mm = 2.61 m
- The Orange path + Red path = 1083 + 12000 = 13083 mm = 13.08 m

Thus, the fiber length difference between clock and signal is 10.47 m.

The effective index of refraction of the fiber is approximately 1.47.

- ⇨ 10.47 m in fiber = 10.47 x 1.47 = 15.39 m in air.
- ⇨ Speed of light in air = 299792458 m/sec
- ⇨ 15.37 m in air ➔ 51.3 ns (Delay between the clock and signal)

Now, taking into account the minimum electrical delay in the clock circuit of 28.3ns and the step size of clock delay setting, 0.575ns, we can calculate the number to use in the "Set clock delay" window to be (51.3 – 28.3) / 0.575 = "**40**".

3.4 Engine TEC Tab

The *Engine TEC* tab (Figure 3-5) presents information about the status of the thermoelectric cooler.

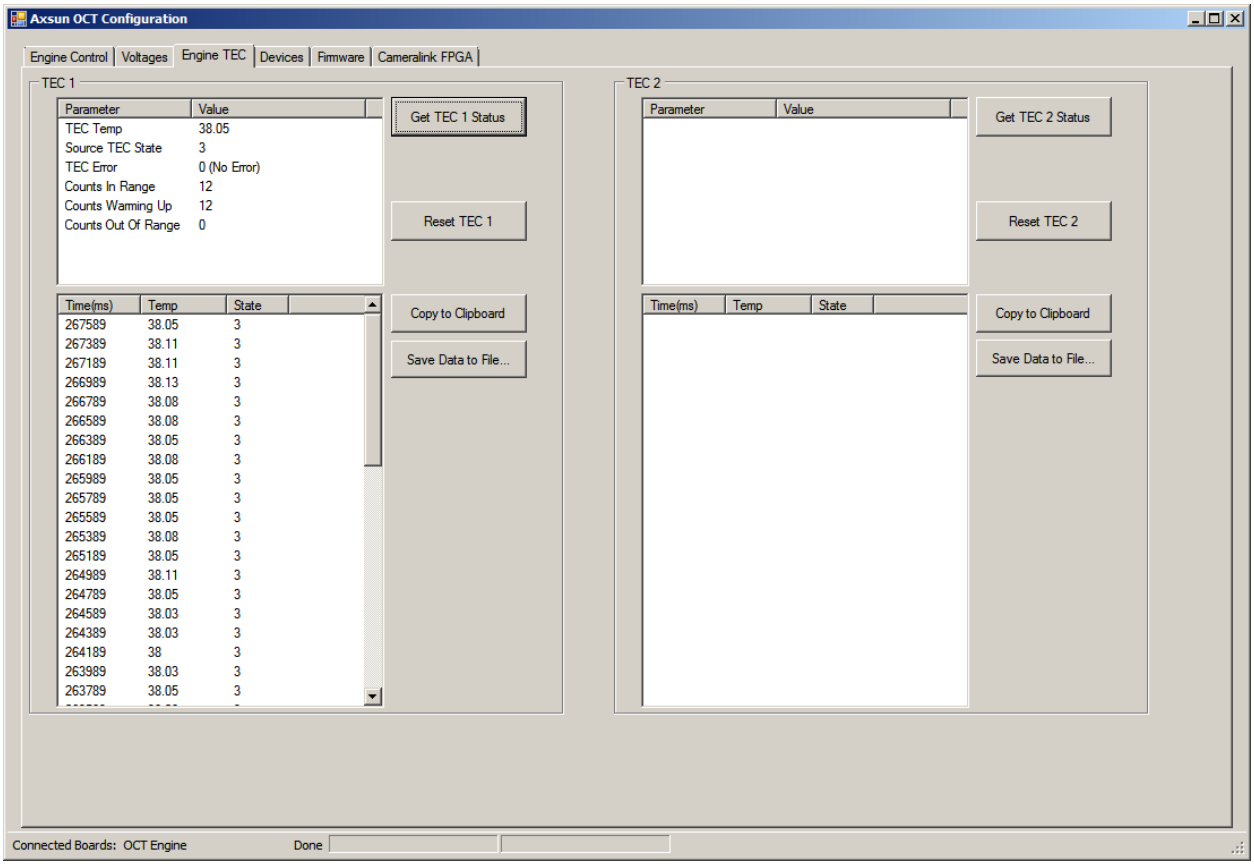


Figure 3-4: The Engine TEC Tab

TEC Control Buttons	
Get TEC Status	Returns the information below.
Reset TEC	Resets the TEC to the state where it was powered on. This is useful when recovering from an error state
Copy to Clipboard	Copies all data from this panel to the clipboard for pasting into Excel® or another application
Save Data to File	Saves all data on this panel to a file.

3.5 Devices Tab

The *Devices* tab (Figure 3-6) displays information about all OCT engines connected to the system. When multiple devices are connected, the user can select a device from this list by clicking on it and pressing the appropriate *Connect* button to this device connects the host application to that specific device.

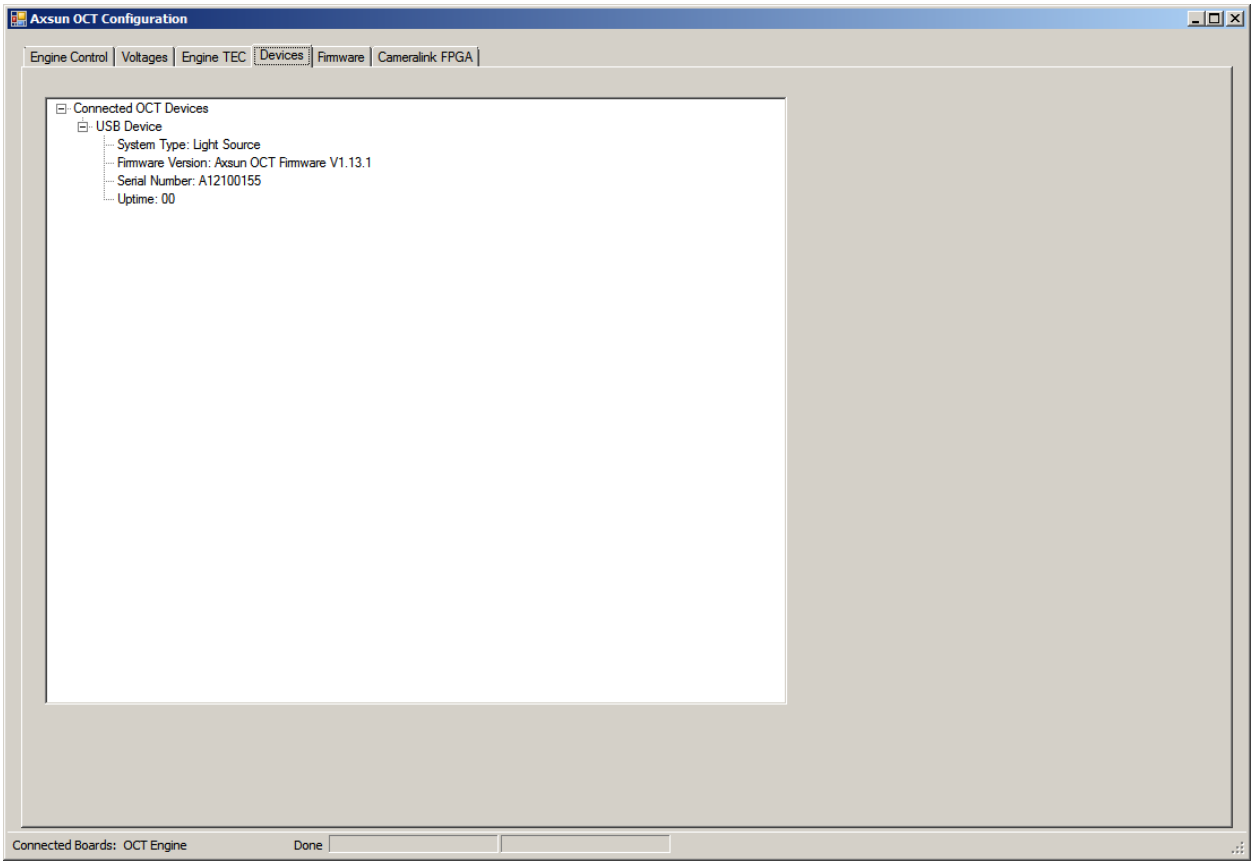


Figure 3-5: The Device Tab

3.6 Firmware Tab

The *Firmware* tab (Figure 3-8) allows downloading of new firmware for the laser driver board.

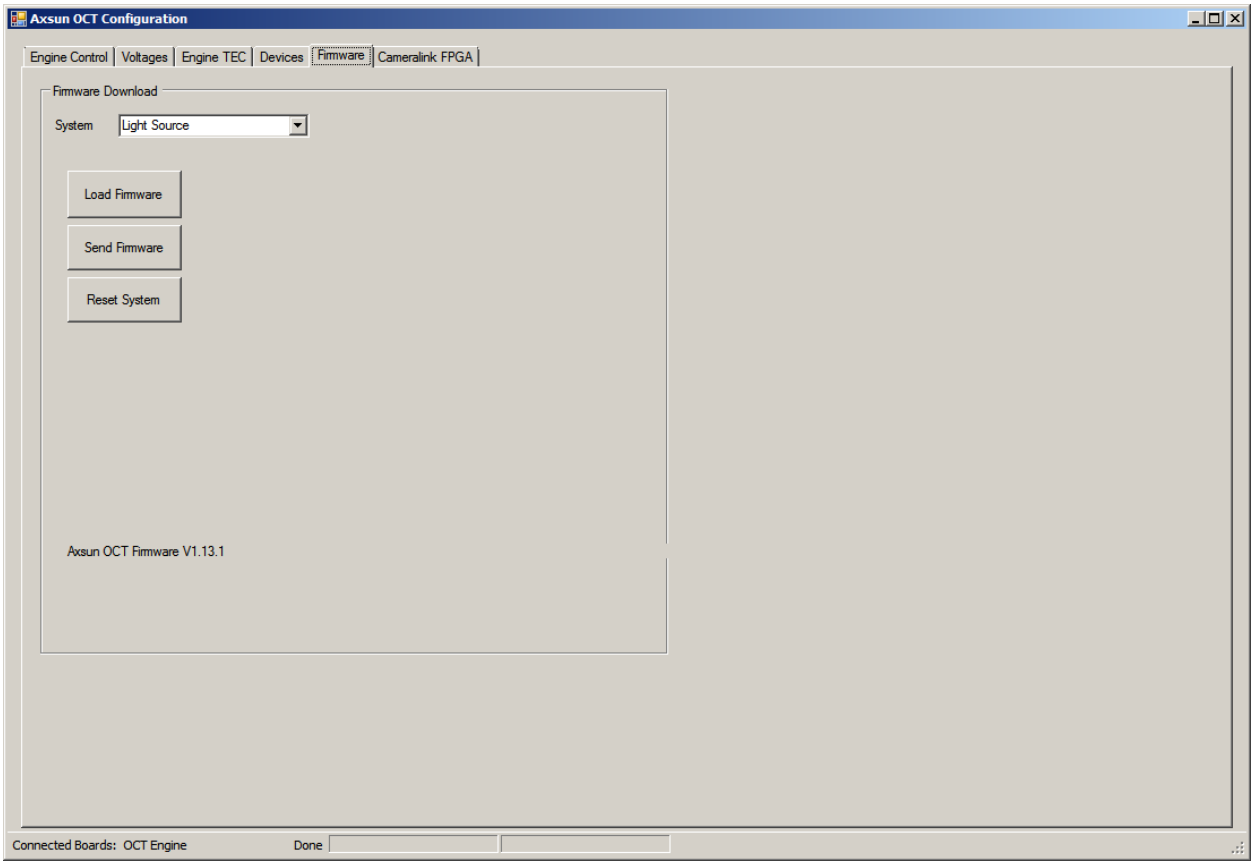


Figure 3-6: The Firmware Tab

To download new OCT engine firmware:

a) Press the *Load Firmware* button to select a .bin firmware file.

b) Press the *Send Firmware* button to send it to the unit and have it written to the flash memory. This will take around 30 seconds. When the *Firmware sent XXXX bytes successfully* message appears, the firmware download process is complete (Figure 3-7).

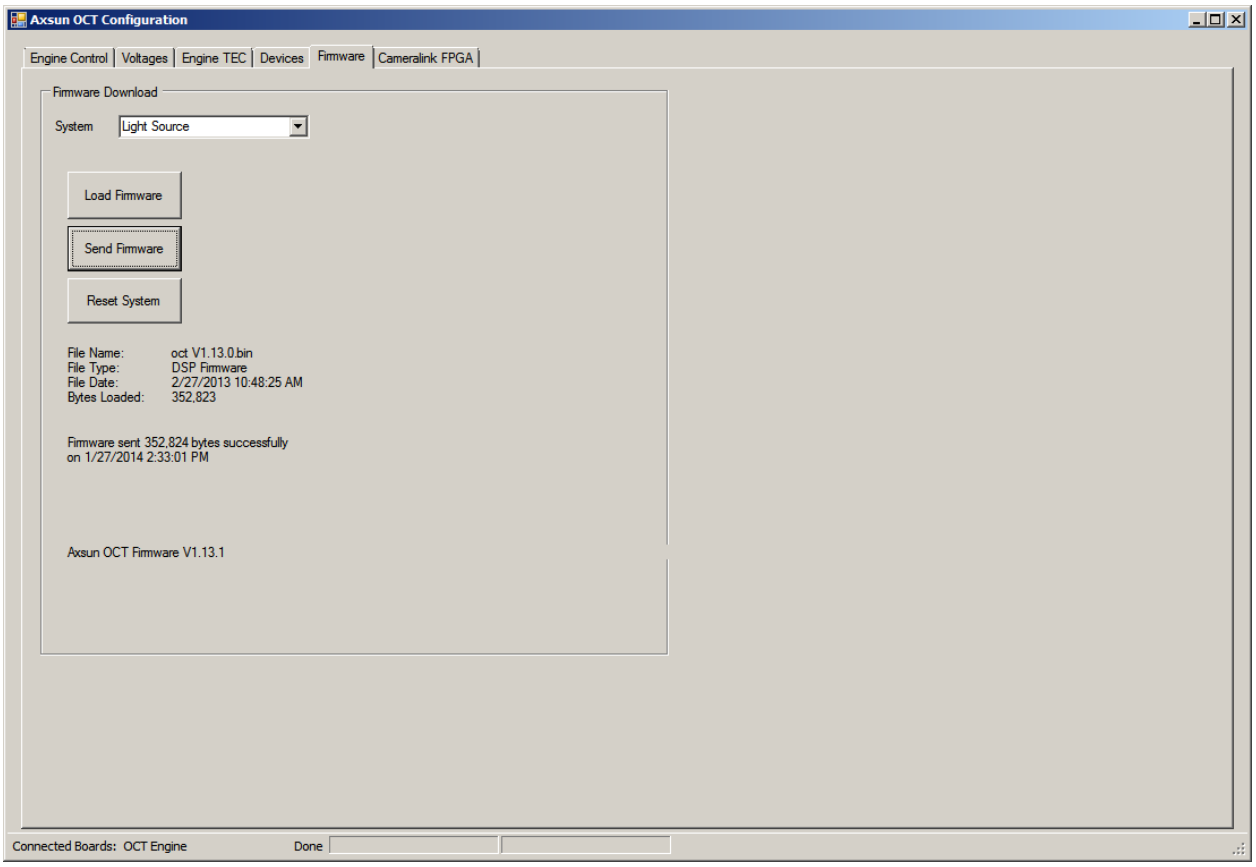


Figure 3-7: The Firmware Tab - Firmware Sent Successfully

c) Press the *Reset System* button to reboot the OCT unit with the new firmware.

Downloading new OCT ADC firmware and Cameralink FPGA software is described in Appendix 3.

3.7 The FPGA Settings Tab

The *FPGA Settings* region describes operation of the optional data acquisition board and is discussed in Appendix 3.

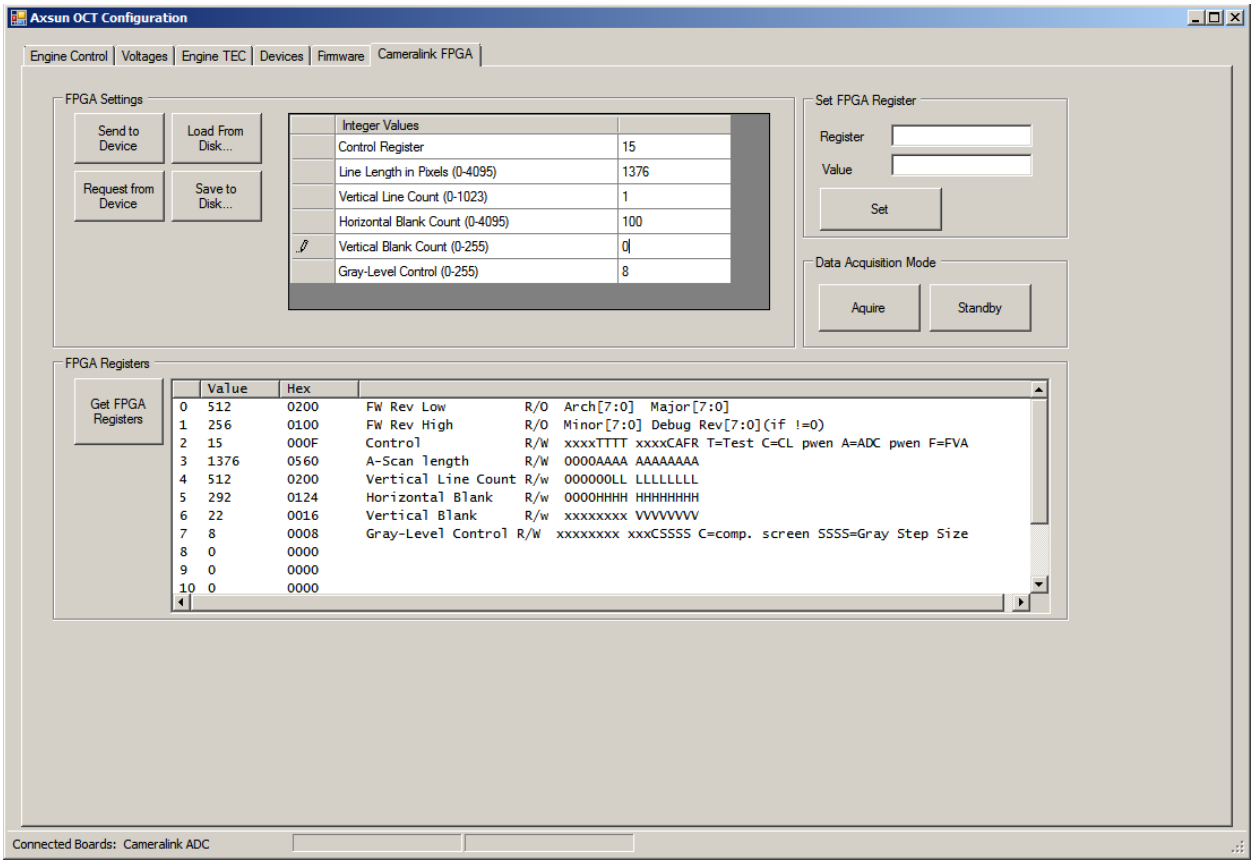


Figure 3-8: The FPGA Settings Tab

4 Operation

CAUTION: Turn off the unit or stop laser output before making or breaking an optical connection to prevent damage to the connection due to high power density in the fiber core.

CAUTION: Note the potential for exposure to laser energy if the system is operated without a fiber optic patch cord attached.

Be sure optical connectors are clean before making a connection, as foreign material can cause burn damage to fiber ends.

For 1060 swept source lasers, the fiber (Corning HI-1060) has a very small core diameter which could cause a higher connector coupling loss. In such cases we recommend trying different patch cords to find a better loss value or loose the connector slightly to find a better loss value.

4.1 Benchtop Unit

To operate the system, turn the Power switch to start the unit. The start sequence takes about 10 seconds during which the Power indicator will blink. During the Start sequence, the engine will undergo a number of self-test protocols and will make preliminary optical cycles. After about 10 seconds, swept spectrum optical energy will be emitted from the Optical output and the *Laser* indicator will be lit.

The delay time should be selected and entered (Section 3.4.2). Once the delay time has been entered, it is stored in the engine and it need not be set every time the system is turned on.

4.2 OEM Unit

Connect the power supply using the adapter cable provided. The start sequence takes about 10 seconds. After about 10 seconds, swept spectrum optical energy will be emitted from the Optical output.

5 Maintenance

CAUTION: There are no user repairable components inside the unit. Do not remove the cover.

Note: If it is necessary to disconnect the fiber optic patchcord from the Benchtop engine, make certain that the end is clean before re-inserting it into the engine. If necessary, carefully wipe the fiber with a lint-free tissue saturated with ethanol. (Use of Cletop fiber cleaners are recommended.)

If abnormal conditions are observed, power down the system and power up again. If the conditions persist, please call Asxun Technologies for assistance.

Appendix 1 Specifications-SSOCT-1060

Wavelength Range (-10 db) (100 nm within this range)	980-1100 nm
Wavelength Center	1040-1060 nm
Average Output Power	Min 15 mW
Sweep Rep Rate[1]	10-100 kHz
Coherence Length[2]	Min 10 mm, Typical 12 mm
Output Connector	FC/APC
OEM Sweep Trigger Output OEM Clock Output	LVDS(1.0 - 1.4V), SATA connector ECL(1.6 - 2.4V) SATA connector
Benchtop Sweep Trigger Output Benchtop Clock Output	TTL(0 - 3.3V), SMA connector 0.2 - 0.8V, SMA connector
Laser Drive	Sine or Linear
Power Input	100-240 VAC, 50/60 Hz
Power Consumption (~25ºC)	12 W (Laser engine alone) 40 W (with Axsun supplied power supply)
Mechanical Dimensions - Stand Alone Version OEM Version	208 x 152 x 76 mm (8.2 x 6.0 x 3.1”) 178 x 114 x 54 mm (7.0 x 4.5 x 2.1”)
Weight - Stand Alone Version OEM Version	1.7 Kg (3.7 Lb) 0.6 Kg (1.3 Lb)

1 The Source operates at a fixed sweep rate within this range

2 Full optical path difference at 50% fringe amplitude.

Appendix 2 Specifications-SSOCT-1310

Wavelength Range (-10 db) (100 nm within this range)	1250-1360 nm
Wavelength Center	1300 - 1310 nm
Average Output Power	Min 18 mW
Sweep Rep Rate[1]	10-50 kHz
Coherence Length[2]	Min 12 mm, Typical 15 mm
Output Connector	FC/APC
OEM Sweep Trigger Output OEM Clock Output	LVDS(1.0 - 1.4V), SATA connector ECL(1.6 - 2.4V) SATA connector
Benchtop Sweep Trigger Output Benchtop Clock Output	TTL(0 - 3.3V), SMA connector 0.2 - 0.8V, SMA connector
Laser Drive	Sine or Linear
Power Input	100-240 VAC, 50/60 Hz
Power Consumption (~25ºC)	12 W (Laser engine alone) 40 W (with Axsun supplied power supply)
Mechanical Dimensions - Stand Alone Version OEM Version	208 x 152 x 76 mm (8.2 x 6.0 x 3.1”) 178 x 114 x 54 mm (7.0 x 4.5 x 2.1”)
Weight - Stand Alone Version OEM Version	1.7 Kg (3.7 Lb) 0.6 Kg (1.3 Lb)

1 The Source operates at a fixed sweep rate within this range

2 Full optical path difference at 50% fringe amplitude

Appendix 3 Axsun Camera Link Data Acquisition Board (DAQ)

A3.1 Overview

The Camera Link Data Acquisition Board (DAQ) is designed to allow users of the OEM version of the Axsun Swept Source Engine to collect OCT Data at a speed of up to 500 MSPS with 12 bit resolution.

The Axsun DAQ Board is designed to integrate seamlessly with the Axsun Swept Source Engine as shown below in Figure A3-1). In this photo, the Axsun DAQ board is integrated within the Axsun SSOCT Engine (between the Engine PC Board and the Fiber Management Tray) and does not increase the footprint of the assembly.

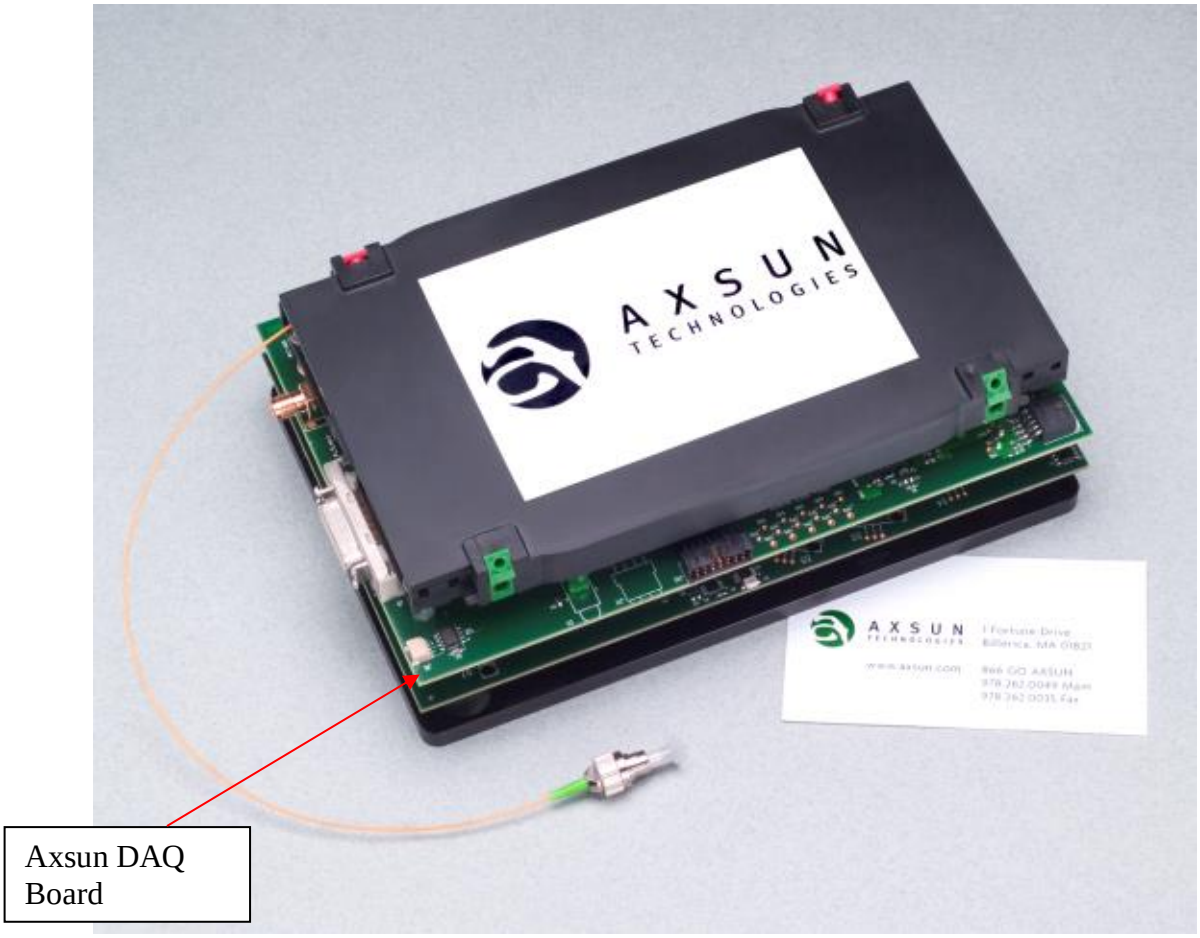


Figure A3-1: Camera Link Data Acquisition Board

A3.2 Installation

The various connectors to the system are shown in Figure A3-2 and A3-3.

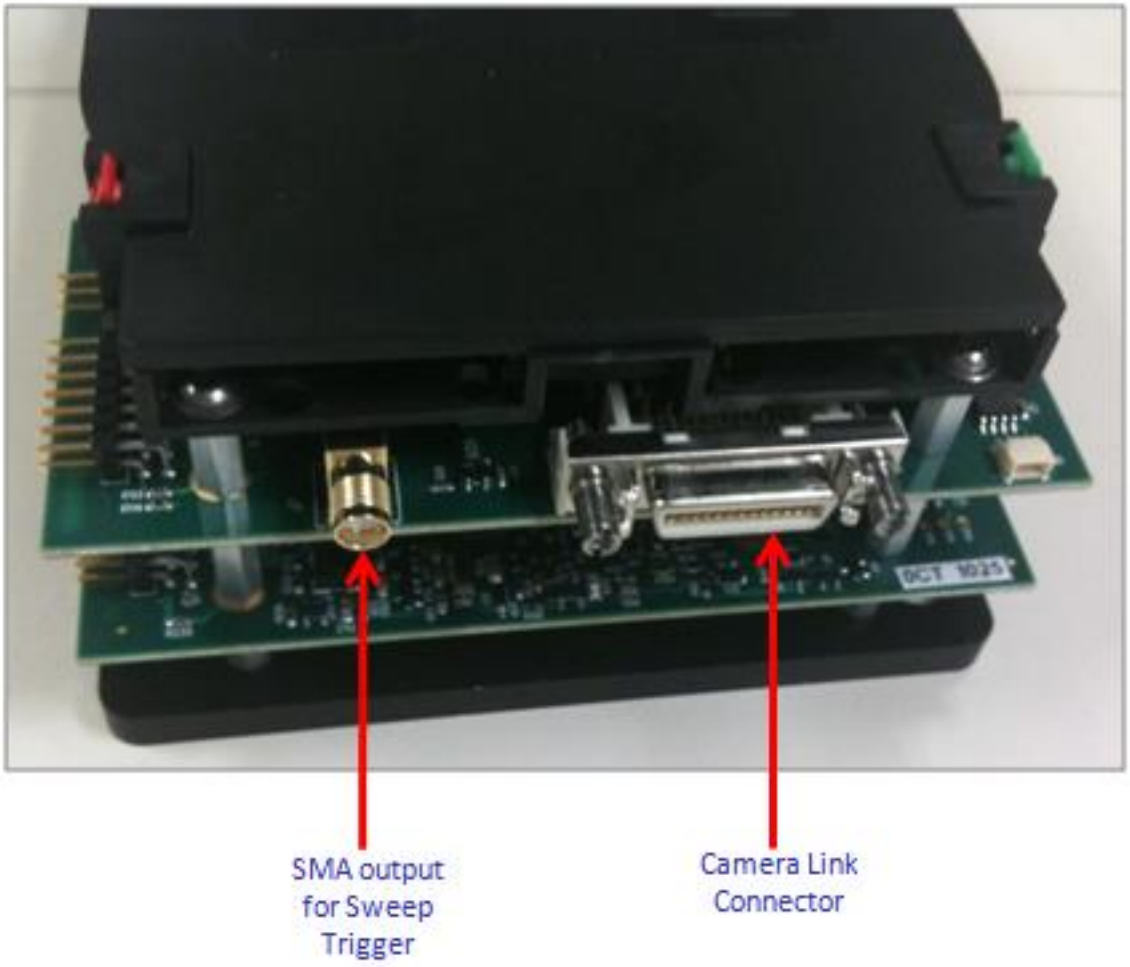


Figure A3-2: Camera Link Side

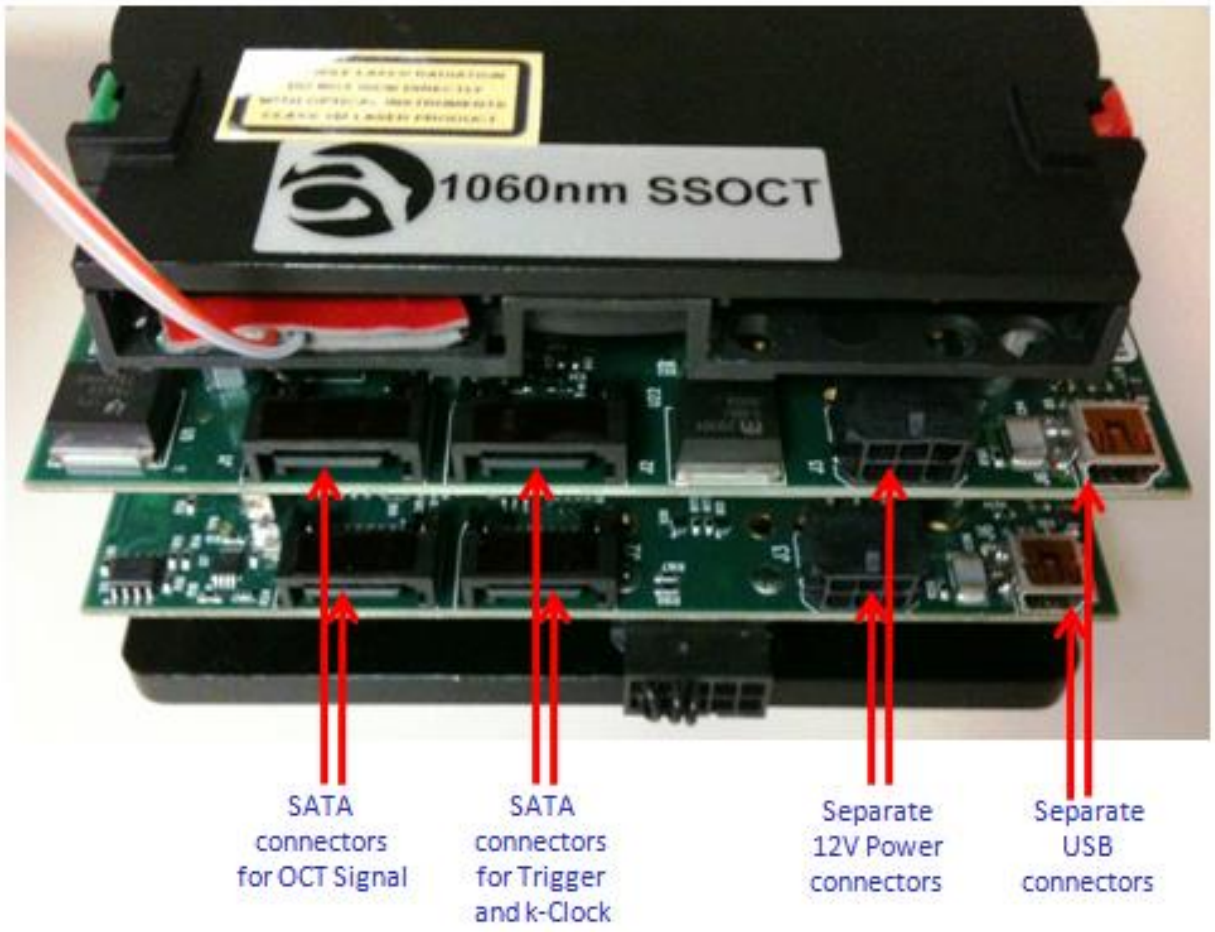


Figure A3-3: SATA Cable Side

Connect the SATA cable for the OCT Signal between the DAQ board and the OCT Engine board as shown in Figure A3.3.

Connect the SATA cable for the Signal and Clock between DAQ board and the OCT Engine board as shown in Figure A3.3.

Connect the power adapter cable into connector J3 on the DAQ board and the OCT Engine board.

Dimensional Information for the SATA connector is shown in Figure A3-4 and pinouts are shown in Figure A3-5.

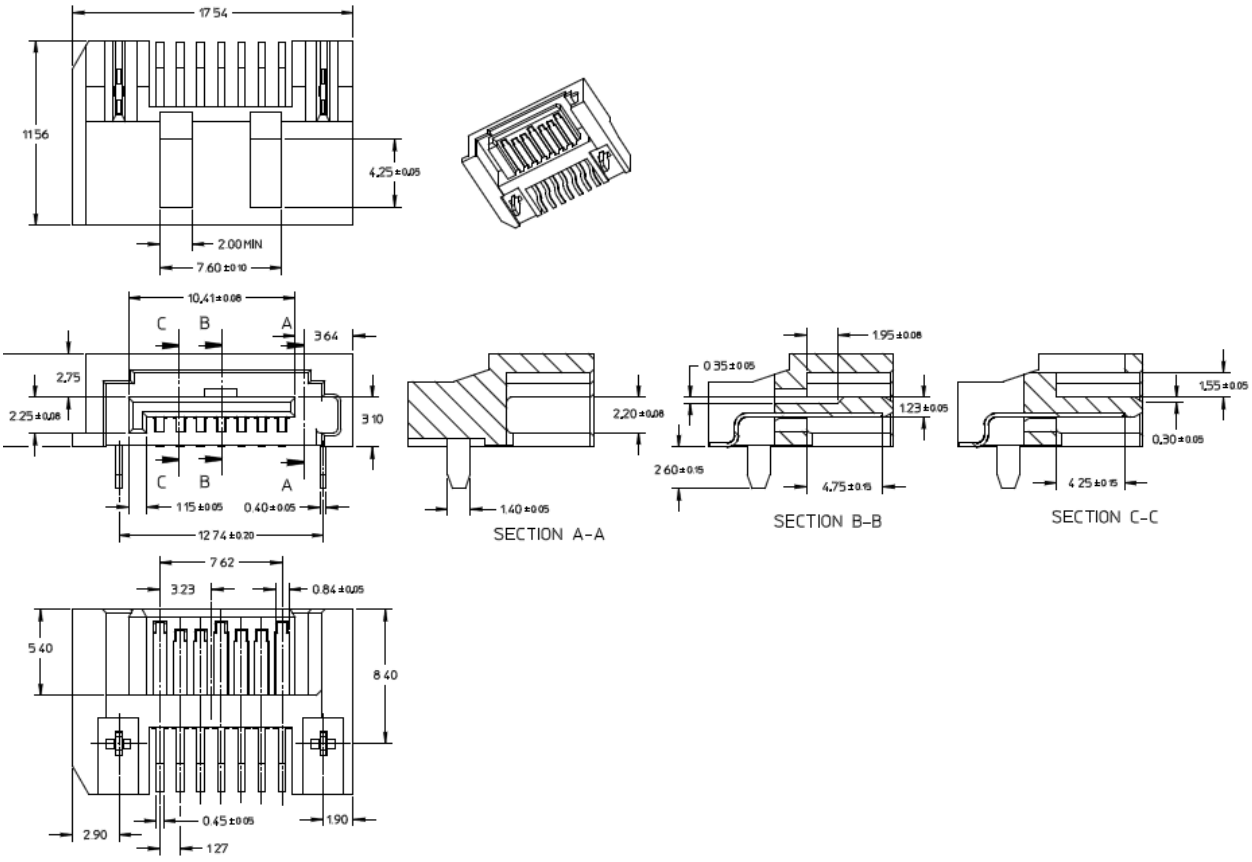


Figure A3-4: Dimensional Information - SATA Connector

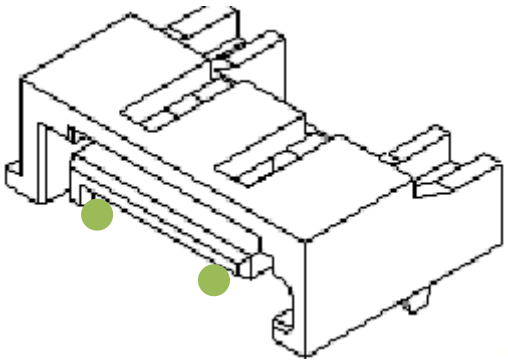


Figure A3-5: Pinouts - SATA Connector

A3.2.1 Output Connection

Connect a camera link cable between the Camera Link socket on the DAQ board (Figure A3-2) and the customer's frame grabber board

A3.3 Control Application Software

The Axsun OCT Swept Source Engine is controlled by a user interface program that is described in Section 3. If the Camera Link Data Acquisition Board (DAQ) is present, three of the tabs will contain additional information (these tabs are grayed out if the DAQ board is not present).

A3.3.1 Device Control Tab

When the software is started, the *Device Control* tab of the *Axsun OCT Configuration* window is presented (Figure A3-6). If the Axsun DAQ Board is installed, the right side of the tab will be activated as shown in Figure A3-6 below.

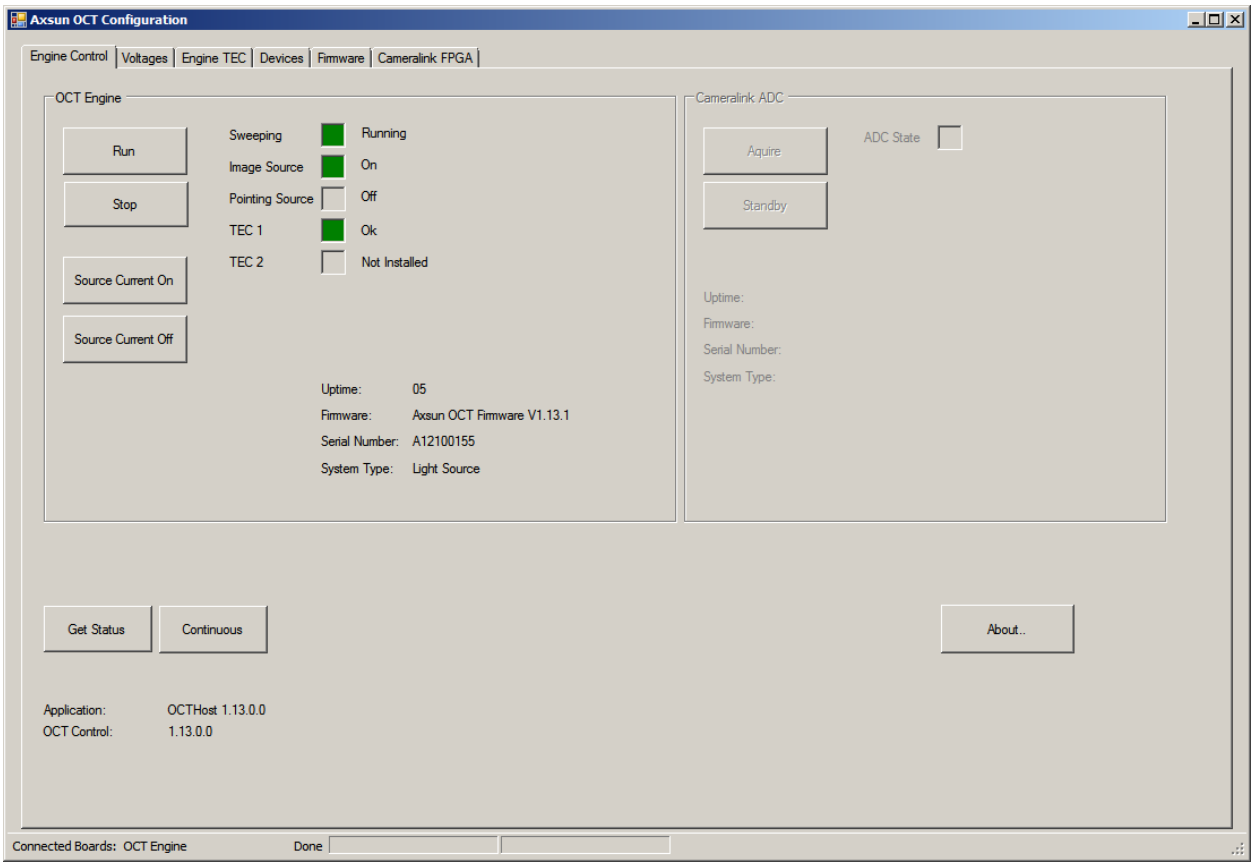


Figure A3-6: The Device Control Tab

To collect data, press the *Acquire* button and to terminate the data collection, press the *Standby* button. When data is being collected, the *ADC State* indicator will appear green.

The *Uptime* field indicates the period of time (in seconds) that the ADC card has been collecting data.

A3.3.2 Firmware Tab

The *Firmware* tab (Figure A3-7) allows downloading of new firmware for the Axsun OCT Engine board, the Axsun DAQ board and the Axsun DAQ board's FPGA bitstream.

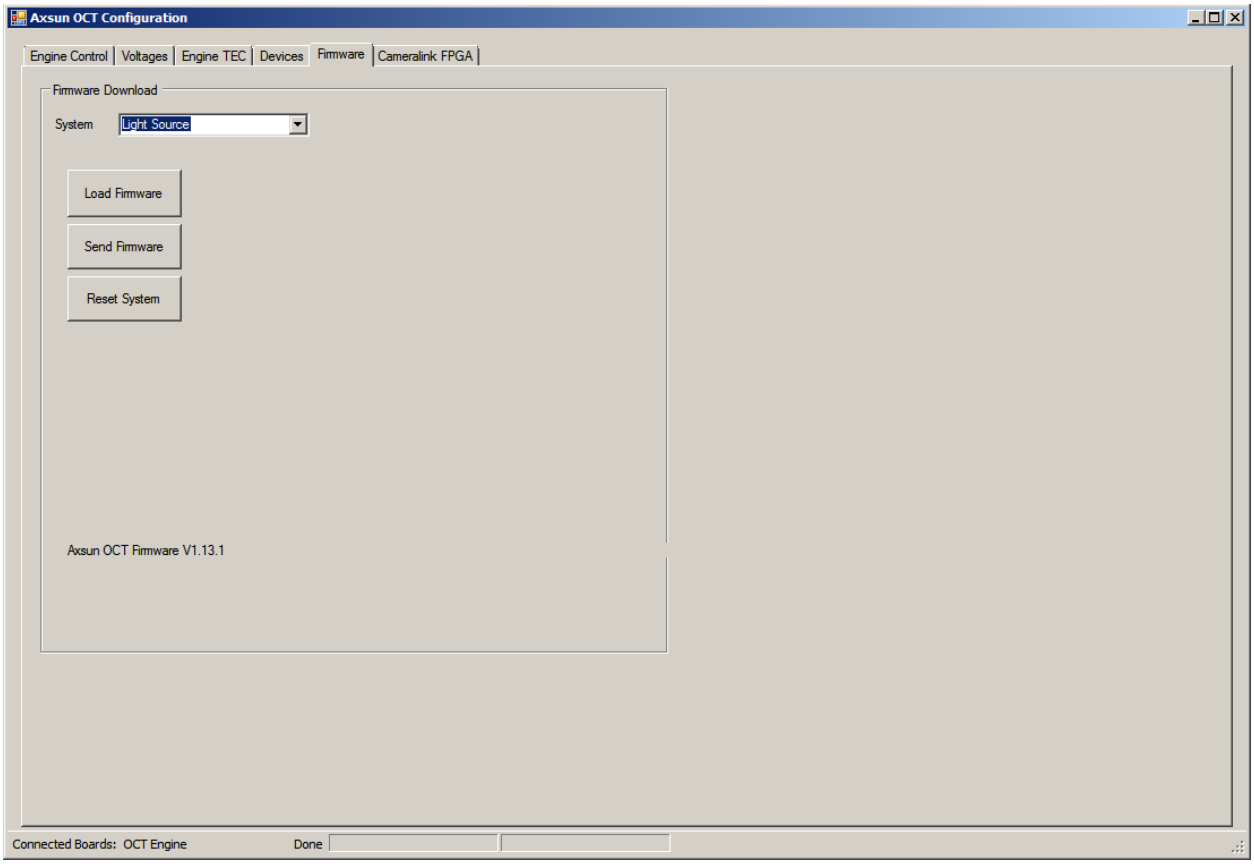


Figure A3-7: The Firmware Tab

The methodology for downloading *Axsun DAQ Firmware* is identical to that for downloading *OCT Engine Firmware* (Section 3.8)

The methodology for downloading *the FPGAbitstream* is identical to that for downloading *OCT Engine Firmware* (Section 3.8).

A3.3.3 FGPA Settings Tab

The *FGPA (Field Programmable Gate Array) Settings* tab (Figure A3-8) is used to establish parameters for data collection.

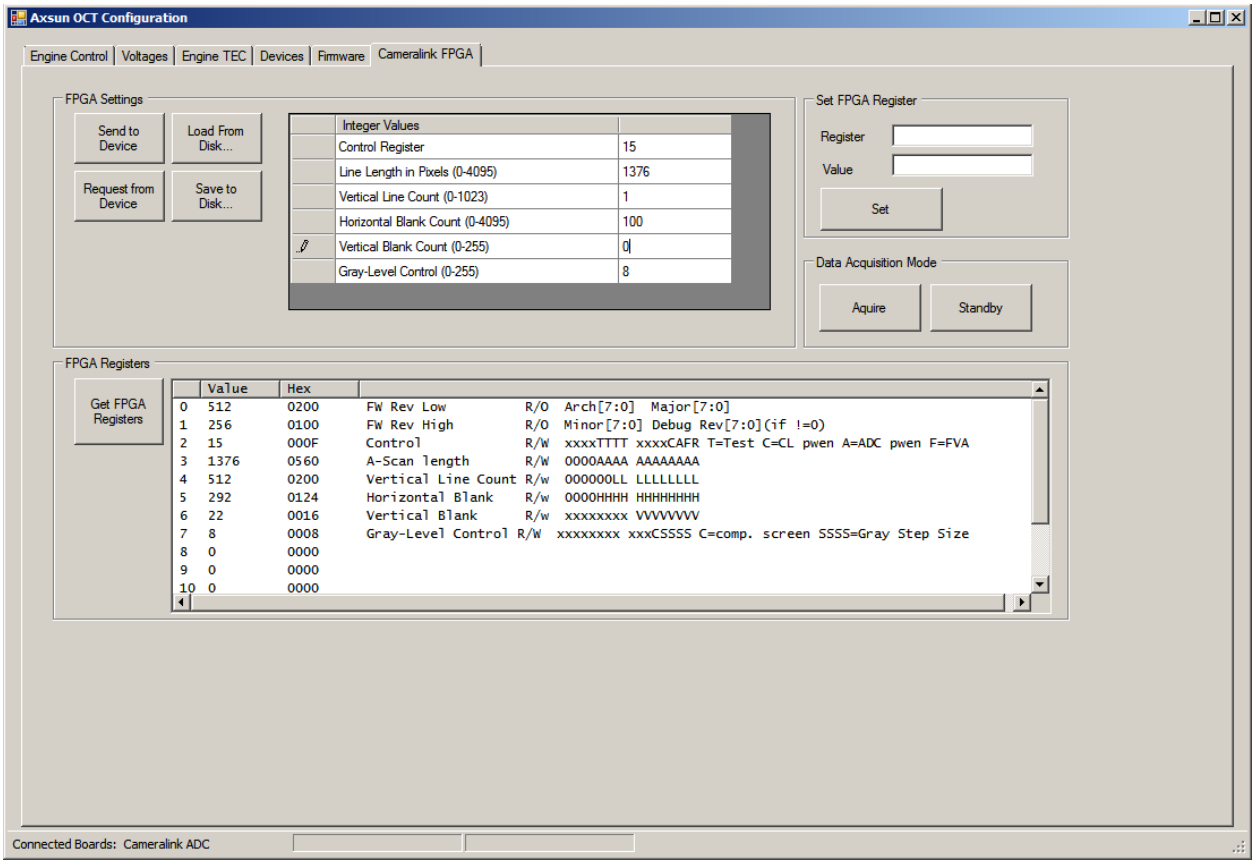


Figure A3-8: FGPA Settings Tab

FPGA Settings

The FPGA Settings parameter values are shown in the large rectangle in the center of the screen. FPGA Settings are stored in flash. These settings are stored and loaded into the FPGA at power up. The control keys are described in Table A3-1. To change a parameter, type in the desired value and click the **Send to Device** button

Table A3-1: FPGA Settings

FPGA Settings	
Send to Device	Sends the settings to the ADC board, writes them to the FPGA and saves them so they are re-loaded at power up.
Request From Device	Reads FPGA settings back from the ADC board.
Load From Disk	Loads a file from the host computer disk with stored FPGA parameters.
Save to Disk	Saves a file to disk of the current parameters.

FPGA Register

The *FPGA Registers* field (Table A3-2) presents the present value and information regarding a number of FPGA registers. The *Get FPGA Registers* button gets the current values from all the FPGA registers.

Table A3-2: FPGA Registers Table

FPGA Register List (16-bit, R/W, unless otherwise indicated)		
0	**FW Rev Low (R/O)**	[15:8] – Minor Revision, [7:0] – Development Revision (if ≠ 0)
1	**FW Rev High (R/O)**	[15:8] – Architecture, [7:0] – Major Revision
2	**Control**	[11:8] – Test Control, [7] – Trigger Select, [3] – CL Power Enable, [2] – ADC Power Enable, [1] – FVAL Enable, [0] – Run Test Control: 0000 – Test Off (data routed from 12-bit ADC) 1000 – Grayscale driven out CL interface Trigger Select: 0 – Sweep Trigger 1 – LVAL (for testing)
3	**A-Scan Length**	[11:0] – Active Pixel Count (default: 1376)
4	**Vertical Lines**	[11:0] – Active Line Count (default: 512)
5	**Hor. Blanking**	[11:0] – Horizontal Blanking Count (default: 292) Note: A-Scan Length + Hor. Blanking = 1668 (100KHz)
6	**Vert. Blanking**	[7:0] – Vertical Blanking Count (default: 20)
7	**Gray Level Control**	[4] – Complement Screen, [3:0] Grayscale Step Size (default: 8)

The *Set FPGA Register* field will set the value of one register. This setting is not saved to flash and is not remembered when the system is rebooted. To edit a value, enter the *Register number* and *Value* in the appropriate fields and press *Set*.

The *Data Acquisition Mode* field buttons have the same action as on the *Device Control* tab (Section A3.2a) and is used to present a test pattern from the DAQ board. (see Section A3-4 for an example).

Table A3-3: ADC Power On/Off

ADC Power On/Off	
On	Enabled the A→D chip on the ADC board
Off	Disables the A→D chip on the ADC board

A3.4 Block Diagram of the Camera Link

The block diagram shown in Figure A3-9 presents the main functional components of the Axsun Camera Link DAQ Board. Inputs to the 12-bit ADC are provided through the SATA connectors J1 and J2. The user can connect to the DAQ board through the USB interface provided. OCT Data is output over the Camera Link connector to an appropriate frame grabber card and an A-scan trigger is provided via an SMA connector for triggering a Galvanometer or probe scanner.

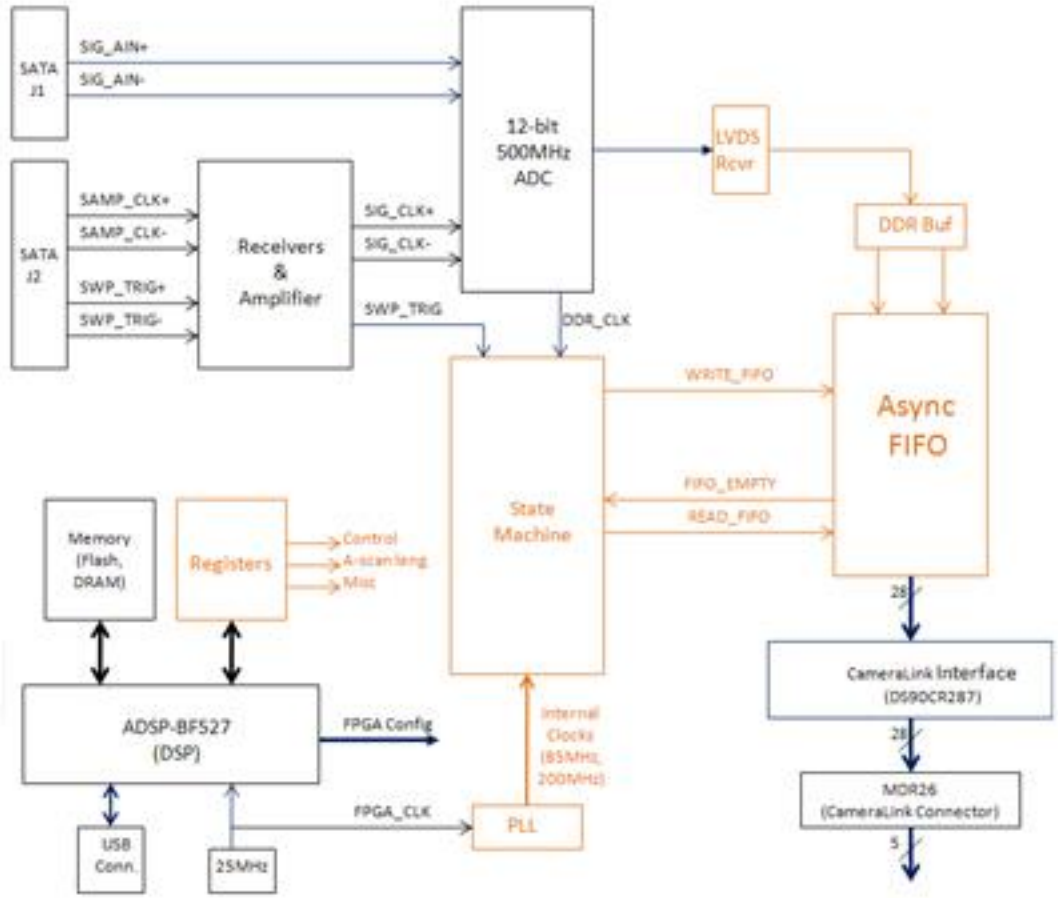


Figure A3-9: Camera Link Block Diagram

A3.5 Example Setup

Integration of the Axsun Swept Source Engine with a Camera Link DAQ Board with the frame grabber in a typical system is shown in Figure 3-10. The Camera Link output of the DAQ board is connected to the Camera Link input of a Matrox Solios frame grabber and the test interferometer is a simple mirror imaging system.

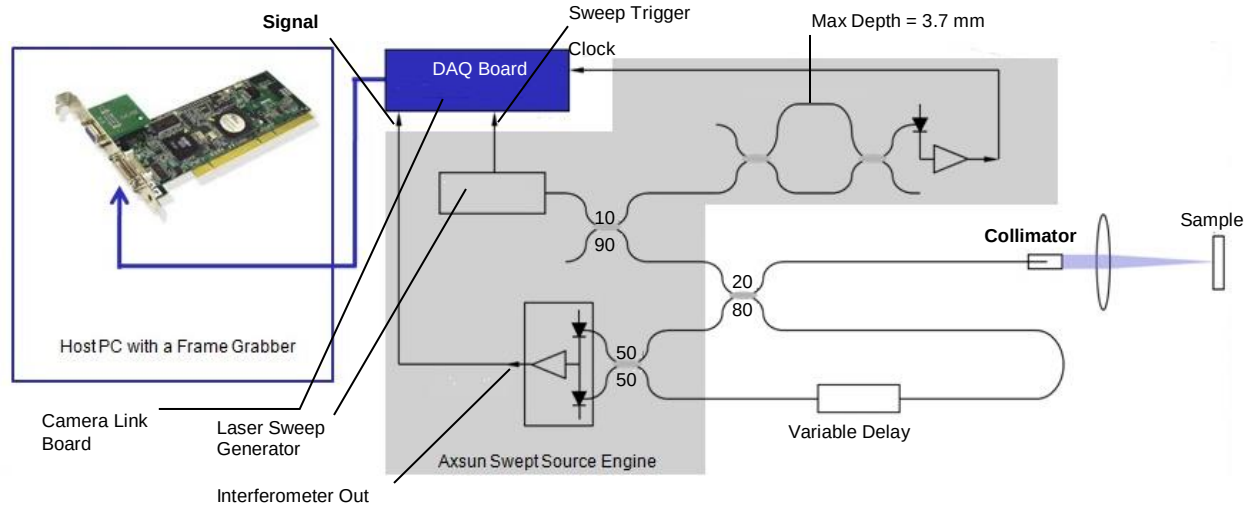


Figure A3-10: A Typical Application Configuration

Axsun DAQ board set up :

- Line Length Pixels = 1376 (number of samples per A-scan)
- Vertical Line Count = 1 (Line-scan mode)
- Horizontal Blank Count = 100 (1 Count corresponds to 6ns)
- Vertical Blank Count = 0 (Line-scan mode)

The Matrox Solios frame grabber was set up as follows using Matrox Intellicam software.

- Camera type = Line Scan
- Pixel clock frequency = 83.33 MHz
- Image size X = 688
- Image size Y = 100

The image size X is always half of the Line Length Pixel size of the DAQ board.

Data collection through the Solios frame grabber can be verified by running Matrox Intellicam software. A typical image such as that in Figure A3-11 will be presented; the pixel count would be 1376 x 100 .
(x = 1376 sample points per A-scan, y =100 A-scans).

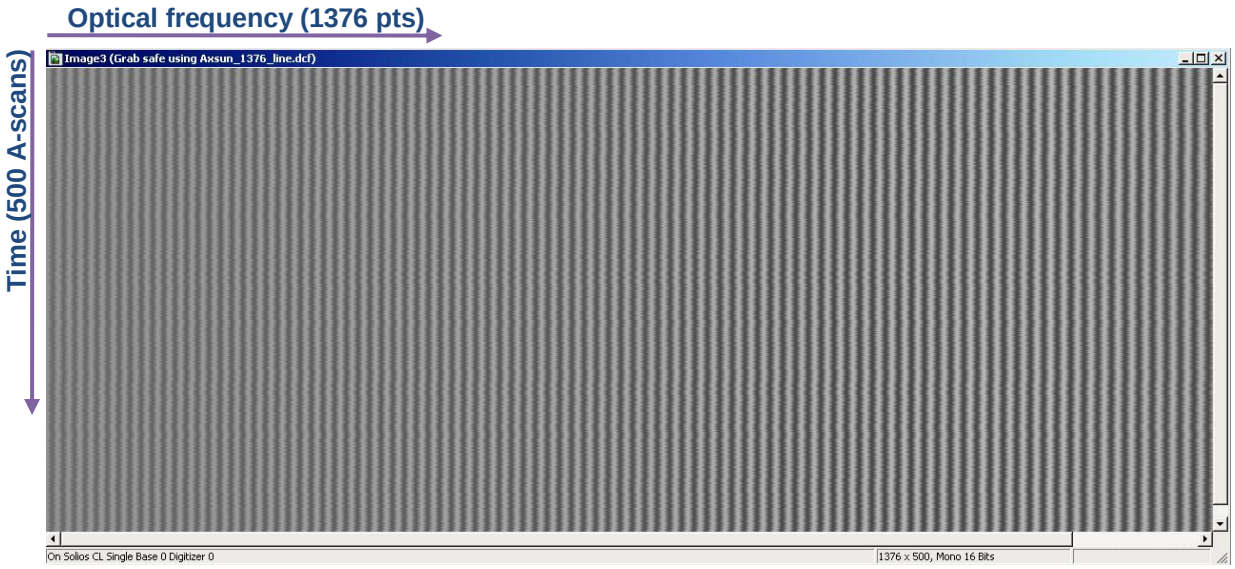


Figure A3-11: Matrox Intellicam software output example.

A3.6 Specifications for Camera Link Board

Max ADC data rate	500 Msamples/sec
Sample size	12 bits (per point)
Camera link configuration:	Base (83.33 MHz, 24 bit pixel data)

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