Micro-Pulse Lidar (MPL) Photonics Type 4B

Installation, Operation, Alignment/Characterization, Repair, and Maintenance Procedure

MAN(MPL)-030.000

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Micro Pulse Lidar System

MPL-4B Series Operations and Maintenance

ARM SGP Site

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Introduction

- Micro Pulse Lidar System*: MPL-4B-532

  Installed Options: MOD-POL-SW (automated polarization control and data acquisition package)

- Class II Laser Product
- Specifications
  - Transmitter: 532 nm, 8 uJ, 2500 Hz
  - Receiver: Maksutov-Cassegrain Telescope 18 cm diameter, Photon Counting Detection
  - Windows 2000/XP based software. SigmaMPL version 2.01.

*Licensed from the National Aeronautics and Space Administration under U.S. Patent No. 5,241,315.

Introduction

MPL Site Requirements

- Electrical:
  - Laser: AC 120V, 8A
  - Lidar Data System and LC Controller: AC 120V, 2A
  - Data Computer: AC120 V, 5A (Customer Furnished)
- Operating Temperature Range: 20-25ºC
- Relative Humidity: < 80%, non-condensing
- Minimize turbulence/convection around beam path

Installation

MPL Shipment Contents

Optical transceiver
Laser power supply + cables
Data Computer + accessories
Lidar Data System unit
Instrument rack, shelf and hardware
USB cable (1)
BNC/BNC cables (2)
Lemo/D-connector cable (1)
Documentation Package + CDs
Shipping cases (2)
Meadowlark Advanced LC Controller D3040 + power supply
BNC/SMA cable (1)
USB cable (1)
DB9 serial M/F cable (1)

Installation

Visual Inspection

MPL system shipment should be inspected by authorized personnel upon receipt.

- Examine shipping cases for visible exterior damage.
- Check contents of shipment for completeness.
- Check interior of case for any signs of mishandling, damage or moisture.
- Remove optical transceiver from case and set on level surface.
    - Open telescope cover and inspect corrector lens.
    - Examine telescope clamp ring -- should be tight and flush with back plate.
- Inspect laser power supply.
- Inspect lidar data system.
- Inspect data computer.
- Check system document set.
- Store MPL system in shipping cases provided in cool and dry facility with controlled access.

- Contact Sigma for any damaged or missing components.

Installation

Rack Installation

19” table top rack supplied with instrument shelf

- 12” x 19” footprint
- 21” (12U) rack space available
- 10-32 screws/washers required

Recommended configuration:

- Lidar Data System mounted on the bottom
- Shelf installed >2” above the data system for
    - Laser power supply – air vents not blocked.
    - Polarization control electronics.
- Additional shelves may be added as necessary for computers etc (not included).
- Power strip with surge suppressor recommended.
- Instrument rack placed on stable, level surface.
- Watch out for trip hazards.

Installation

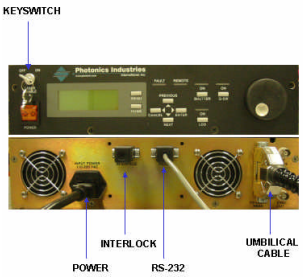
MPL Transceiver Installation

- Handle/lift MPL using vertical support members.
    - Transceiver weight ~50 lbs.
- MPL placed on stable, level surface. Use ¼" clearance holes to bolt down system if possible
- Proximity to instrument rack: ~3'.
- Adjust elevation angle of MPL if required using 5/32 balldriver/Allen key.
- Unobstructed line of sight between telescope aperture and window or hatch.
- MPL installation must be approved by laser safety officer on site.

Interconnections

Laser Power Supply:

- Umbilical cable from transceiver to D-connector on back panel. Retaining screws must be fastened.
- DB9 connector bundled in the umbilical cable to D-connector marked INTERFACE. (Shutter interlock).
- 3' BNC cable from SYNC OUT to lidar data system SYNC.
- AC power cord to outlet.



Lidar Data System:

- USB cable to computer
- 50-pin D-connector to DATA connector on lidar transceiver. Retaining screws must be fastened.
- 5' BNC cable from DET1 to DET OUT on lidar transceiver.
- AC power cord to outlet.

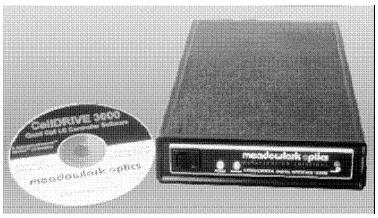
Interconnections

LC Controller:

- SMA cable from Channel 1 output to optical transceiver POL CTRL
- Lemo cable to optical transceiver TEMP CTRL
- 2.5' serial cable to data computer COM1 port.
- Power connector to AC power adapter/outlet.

Computer:

- MPL system connections as above
- Keyboard, mouse, monitor, network, power.



Operations

Power On Sequence

- Laser – Leave laser power supply plugged in for ~10 minutes before starting operations.
  - Laser power supply should be plugged in. The power strip/outlet must be energized.
  - A short beep indicates OK upon plugging in.
  - Cooling fan is operational, even when the laser main power switch is in the OFF position.
  - Temperature controllers inside the lasers are active.
- Power ON – laser, data system, LC controller, computer and monitor
  - Long beep from laser indicates power on. Display shows SHG TEMP and initializes to control screen.
  - Verify USB connection between computer and data system. The USB device icon should appear on the system tray on the bottom right of the screen.

Operations

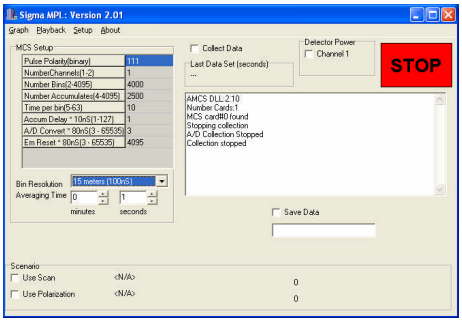
Laser Power On Sequence (Front Panel)

- Turn key switch on front panel to the ON position
  - Q-switch LED will light up.
  - LDD, Shutter, Fault LEDs -- off.
- Press LDD key – LED lights up. This turns on the laser diode driver.
- Press MENU key, select Diode Settings and press ENTER
- The current setting flashes. Press ENTER to change the value.
- Press PREVIOUS/NEXT KEY to adjust current value.
- Set current to approximately 0.6A (varies by system). Press ENTER.
- Press SHUTTER key. LED turns on indicating emission.
- Open telescope cover. Green laser emission from the telescope.
- Press SHUTTER key to turn off emission.

Operations

Data Acquisition System Interface and Configuration

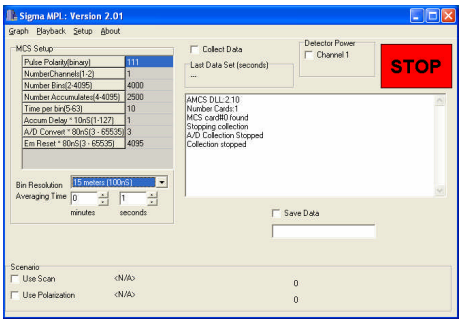
- Data acquisition program: SigmaMPL.exe (Current version 2.01)
  - Default path C:\MPL
  - Click on shortcut or program icon to run program.
  - MPL control screen appears as shown. MCS card#0 found.



Operations

Data Acquisition System Interface and Configuration

- Select range resolution and averaging time from the pull-down menus.
- Check “Use Polarization” box for LC controller operation.
  - Select polarization parameters file from dialog box.



Operations

Data Acquisition System Interface and Configuration

- Polarization control file structure
  - Text/ASCII format. Use notepad to edit as required.

```
;This is a comment line. LC control voltage (Volts).
2.445, 0, 0, 0
4.250, 0, 0, 0
```

  - LC controller supports up to 4 LC retarders.
  - LC output 1 is used as default. Other values are set to 0 (or not).
  - Program displays number of polarization states in file in the control window.
  - Program steps through all values listed in file, one setting per averaging period.
  - The program cycles through the file until operation is terminated.
  - Note: COM port options are defined in config.ini configuration file in the MPL folder.

Operations

Data Acquisition System Interface and Configuration

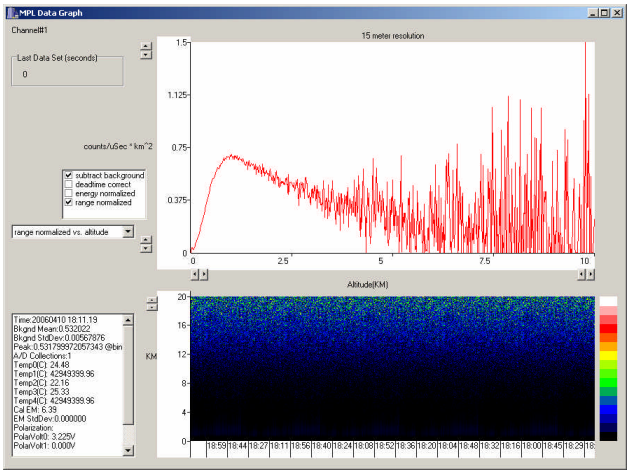
- So far…
  - Range resolution set
  - Averaging time set
  - Polarization control set

- Next…
  - Turn on detector – check box for “Detector Power Channel 1”
  - Check “Save Data” box if required.
  - Check “Collect Data”
  - Click on “Graph”. Graph window appears.
  - Signal graph and time series plots are displayed.
  - Laser pulse energy, temperatures, polarization state, background data reported.

Operations

Data Acquisition System Interface and Configuration

- MPL Graph Window



Operations

Data Acquisition System Interface and Configuration

Dark counts measurement

- Laser Q-switch operating
- Laser shutter closed, no emission
- Range resolution = 30 m, Averaging time = 30 seconds
- Polarization control not required
- Telescope lid closed
- Collect data

Data

- Background reported in graph window represents dark counts in 1/µs units.
- Typical values < 0.0001 (100 cps) for the MPL-4B series detector.
- Detector data sheet is provided with instrument from manufacturer.

Operations

Data Acquisition System Interface and Configuration

After pulse measurement

- Laser Q-switch operating
- Laser shutter open, laser current adjusted to 6µJ pulse energy.
- Range resolution = 30 m, Averaging time = 30 seconds
- Polarization control not required
- Telescope lid closed
- Collect data. Set graph display to counts per bin.

Data

- Background reported in graph window represents after pulse background in 1/µs units.
- Typical values ~ 0.0002 (200 cps) for the MPL-4B series. Requirement < 0.0005.
- Width of initial pulse ~ 3 bins. (Factor of 3 improvement over the MPL-4B-527 systems).

Operations

Data Acquisition System Interface and Configuration

Atmospheric measurements

- Laser Q-switch operating
- Laser shutter open, laser current adjusted to 6µJ pulse energy.
- Range resolution = 30 m, Averaging time = 30 seconds
- Polarization set with selected configuration file.
- Telescope lid open.
- Collect data. Set graph display to counts per bin.

Data

- Background reported in graph window represents 55-60 km range mean signal in 1/µs units.
- Typical values ~ 0.2 for the MPL-4B series. Requirement < 0.5.
- New file created upon start up (if enabled) and then every hour at 00 minutes.

Operations

Data Acquisition System Interface and Configuration

Display Types

- Counts versus range bin index. Units 1/µs.
- Altitude versus range normalized signal. Units 1/µs*km$^{2.}$
- Altitude versus log range normalized.
- False color time series image.

Data Format

- Binary format – little endian
- 128 byte header
- Data block – float 32 type
- Photon counts stored without dead time correction
- Background counts stored in header
- Data units 1/µs.

MPL-4B Training, ARM SGP, May 2006

Operations

Data Acquisition System Interface and Configuration

Playback of previously recorded files

- From MPL control window, click on Playback—Start
- Select MPL data file. Note SigmaMPL files use the YYYYMMDDHHMM_0.MPL name format.
- Additional playback control options appear at the bottom of the control window.
- Graph can be displayed with header information read back from the data file.

Operations

Data Acquisition System Interface and Configuration

System Shutdown Procedure

- Close MPL graph window
- Uncheck “Collect Data” box. Wait for “Collection Stopped” message.
- Close laser shutter using SHUTTER key on laser power supply.
- Uncheck “Detector Power” box.
- Exit from SigmaMPL program.
- Turn LDD off on laser control.
- Turn laser key switch to OFF.
- Turn power switch to OFF.
- Turn Lidar Data System off.
- Turn LC controller off.
- Replace telescope lid carefully – avoid touching the corrector lens surface.

Operations

Working with the native data format in C/C++ or Matlab type environments

- **** Note: All data in in little-endian format. ****
- unit_num = fread(fid, 1, 'uint16'); % Serial Number of instrument
- ver_num = fread(fid, 1, 'uint16'); % Software version number*100
- yr = fread(fid, 1, 'uint16');
- mon = fread(fid, 1, 'uint16');
- dt = fread(fid, 1, 'uint16');
- hr = fread(fid, 1, 'uint16');
- mn = fread(fid, 1, 'uint16');
- sec = fread(fid, 1, 'uint16');
- shots_sum = fread(fid, 1, 'uint32'); % Number of shots in integration period (1 sec = 2500 shots)
- trig_freq = fread(fid, 1, 'uint32'); % 2500 Hz PRF
- emon = fread(fid, 1, 'uint32')/100; % Energy monitor reading in uJ, stored as emon_uJ*100
- det_temp = fread(fid, 1, 'uint32')/100; % Temp 0 Detector temperature det_C*100 Celcius
- temp1 = fread(fid, 1, 'uint32'); % Temp 1, not used
- tele_temp = fread(fid, 1, 'uint32')/100; % Temp 2, Telescope temperature tele_C*100 Celcius
- laser_temp = fread(fid, 1, 'uint32')/100; % Temp 3, Laser head temperature temp_C*100 Celcius
- temp4 = fread(fid, 1, 'uint32'); % Temp 4, not used

Operations

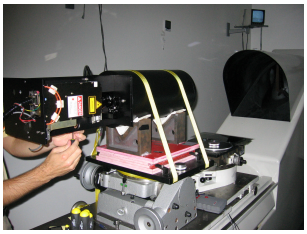
Working with the native data format in C/C++ or Matlab type environments

- bkg = fread(fid, 1, 'float32'); % Background signal mean in counts/microsecond
- bkgstd = fread(fid, 1, 'float32');% Background signal standard deviation in counts/microsecond
- numchannels = fread(fid, 1, 'uint16'); % Number of detector channels
- numbins = fread(fid, 1, 'uint32'); % Number of bins stored in data block
- bin_time = fread(fid, 1, 'float32'); % Range bin time (100ns = 15m resolution etc)
- max_range = fread(fid, 1, 'float32'); % maximum range up to which data is stored (usually ~60,000 m)
- deadt_flag = fread(fid, 1, 'uint16'); % Dead time correction flag, 1=corrected, default=0
- scan_flag = fread(fid, 1, 'uint16'); % scanning enabled=1, disabled=0; % Not applicable
- pol_flag = fread(fid, 1, 'uint16');% Polarization control enabled=1, disabled=0;
- az_deg = fread(fid, 1, 'float32');% azimuth angle degrees % Not applicable
- el_deg = fread(fid, 1, 'float32');% elevation angle degrees % Not applicable
- comp_deg = fread(fid, 1, 'float32');% compass readout degrees % Not applicable
- pol_v1 = fread(fid, 1, 'float32');% Polarization control voltage setting volts
- pol_v2 = fread(fid, 1, 'float32');% Polarization control voltage setting volts not used
- pol_v3 = fread(fid, 1, 'float32');% Polarization control voltage setting volts not used
- pol_v4 = fread(fid, 1, 'float32');% Polarization control voltage setting volts not used
- reserved = fread(fid, 24, 'char');% Future expansion
- Datablock array: 4 bytes/bin float32 type, array has numbins members

MPL Alignment and Characterization

Laser performance verification

- Wavelength
- Energy level and stability
- Beam quality
- Optimal filter matching for each system



Telescope characterization

- Mechanical interface
- Secondary mirror mask
- Spot size measurement

• All optical tests and procedures are performed on a 106” focal length collimator bench at a nominal laboratory temperature of 23°C.

MPL Alignment and Characterization

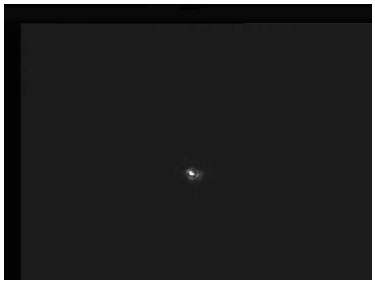
Aft-optics assembly

- Each aft-optics assembly undergoes fit check and certification.
- Optics are bonded into mounts using 3M Scotchweld 2216 epoxy.
- Laser head is pre-fitted for adapter for first stage beam expander at factory.
- Laser head is purged sealed unit.
- Beam position and quality is tightly controlled in transmit/receive paths.
- Laser interlock installed for CDRH compliance.
- Transmit/receive path alignment done on collimator bench.
- Alignment verified using back illumination through detector fiber.
- Intermediate alignment and focal plane images are recorded.
- Overall system transmission and other optical parameters are measured and recorded.

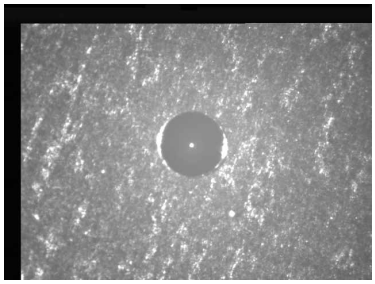
• All optical tests and procedures are performed on a 106” focal length collimator bench at a nominal laboratory temperature of 23°C.

MPL Alignment and Characterization

Images recorded during alignment



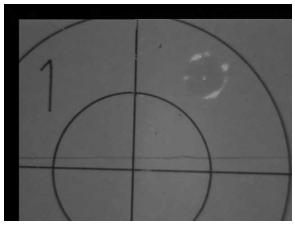
Telescope spot size image

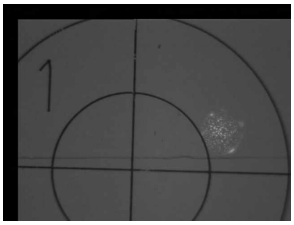


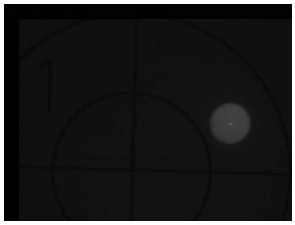
Pinhole-collimating lens focus image

MPL Alignment and Characterization

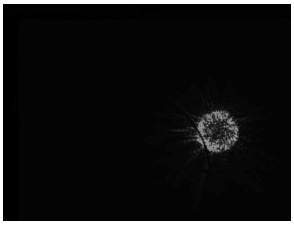
Images recorded during alignment







System boresight image



Fiber assembly image

MPL Alignment and Characterization

Calibration and Testing

- NIST traceable energy monitor calibration performed.
- Output beam uniformity (energy balance) is checked.
- Polarization control is tested. Co-/cross polarization control voltages established.
- Dark counts verification.
- After pulse measurements.
- Clear sky measurements (vertical profiles) using c-polarized mode.
- Horizontal line of sight measurements using c-polarized mode.
- Product labeling for CDRH compliance.

- All optical tests and procedures are performed on a 106” focal length collimator bench at a nominal laboratory temperature of 23°C.

Maintenance

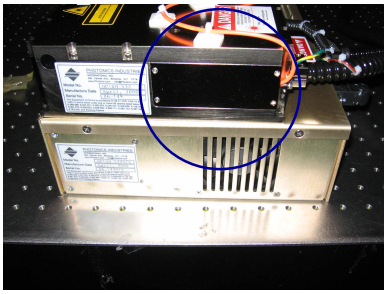
Routine Maintenance

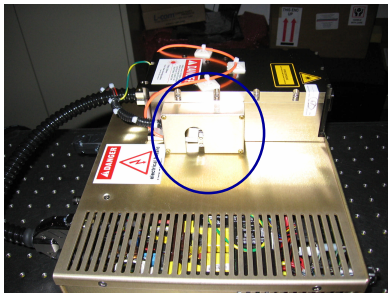
- Shutdown MPL system.
- Inspect telescope surface. Using pressurized air, clean off any dust deposit on the corrector lens.
- Avoid cleaning the telescope optics with methanol or other solvent.
- Clean MPL transceiver surfaces with lint free cloth and methanol.
- Check areas around the laser power supply to ensure free circulation of air.
- Periodically transfer the stored MPL data to archive.

Maintenance

Pump Diode Replacement

- Expected lifetime > 10,000 hours. Symptoms: Drop in laser output power.
- Pump diode side-mounted on laser head.
- Fiber coupled to laser head – SMA connector.
- Tools and materials required: Phillips screw driver, 5/32 balldriver, 0.050” Allen key, anti-static wrist strap, fiber cleaner or lens tissue, heat sink compound and power meter.





Maintenance

Pump diode replacement procedure (Trained/authorized personnel only).

- Use anti-static wrist strap throughout this procedure.
- Shut down MPL system.
- Unplug laser power supply and disconnect the umbilical cable.
- Using a 5/32 ball driver release the elevation adjustment screws. Swing the transceiver to a horizontal position, with the heat sink side down. Tighten the adjustment screws.
- Using a Phillips head screwdriver, remove all screws from the smaller of the two MPL aft-optics access panels. This should be on the top side of the assembly.
- Locate the access panel on the laser head for the fiber end of the pump diode. The panel is flush with the laser head and secured by four button head screws. Use the 0.050” Allen key to open the panel.
- Carefully unscrew the SMA end of the fiber from the mount. Retrieve the coiled up section of the fiber.
- Unscrew the cover for the pump diode housing located on the laser head. There may be wire ties that have to be cut to release the fiber.
- Disconnect the diode power connector. NOTE THE POLARITY OF THE PLUG.
- Remove four screws holding the pump diode module to the TEC assembly.

Maintenance

Pump diode replacement procedure (cont'd)

• Apply a small amount of heat sink compund to the bottom of the replacement diode.

• Secure the diode to the TEC assembly using four screws. Clean off any excess grease with a wipe or cloth.

• Plug in the power connector across the pins. ENSURE CORRECT POLARITY OF THE PLUG.

• Clean the fiber end of the pump diode with a fiber cleaner.

• Pull up the interlock plunger to defeat interlock.

• Test the fiber output by powering up the laser power supply and using LDD control to increase current to ~ 1.5A. The output of the diode should be 1W. Turn the current down, and shut off the laser power supply. Note the current setting for 1W output.

• Install pump diode housing cover.

• Wind the fiber loosely in a 2" diameter loop and secure the SMA connector in the laser head.

• Close access panel with the four screws. Use wire ties to secure fiber.

• Close laser access panel on MPL.

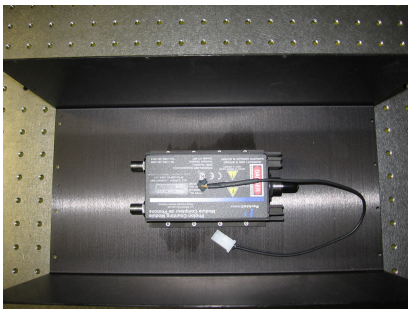
Maintenance

Detector Replacement Procedure (Trained/authorized personnel only)

Symptoms

• No output counts. Likely cause of failure – high voltage bias circuit failure inside detector module.

• Very high count rate with no correlation to signal. Likely cause of failure – photocathode damage.



Maintenance

Detector Replacement Procedure (Trained/authorized personnel only)

- Use anti-static wrist strap throughout this procedure.
- Shut down MPL system.
- Disconnect DATA cable from the MPL transceiver.
- If required -- Using a 5/32 ball driver release the elevation adjustment screws. Swing the transceiver to a vertical position. Tighten the adjustment screws.
- Using a Phillips head screwdriver, remove all screws from the larger of the two MPL aft-optics access panels. This should be on the heat sink side of the assembly.
- CAREFULLY -- slide out the panel about half way. Support panel in this position, while disconnecting the following:
    - DC power connector
    - BNC output connector
    - Temperature sensor connector (white)
    - FC fiber connector. Use a FC cap if available or wrap free fiber end in lens tissue.
- Slide the panel out all the way and place on a clean work surface with heat sink down.

Maintenance

Detector Replacement Procedure (cont'd)

- Using a balldriver remove the eight screws holding the detector to the panel and heat sink assembly.
- Clean heat sink grease from the bottom surface of the detector. Set aside failed detector for shipping to Sigma.
- Remove new detector from package. Note down serial number. Update MPL system information file with new detector data.
- Apply a small amount of heat sink compound to the bottom of the detector. Spread evenly to form a thin layer.
- Place detector and align the eight screws. Secure detector to panel and heat sink.
- CAREFULLY -- slide in the panel about half way. Support panel in this position, while re-connecting the following:
    - DC power connector
    - BNC output connector
    - Temperature sensor connector (white)
    - FC fiber connector.
- Slide the panel in all the way and secure all panel screws.

Troubleshooting

Laser

• Laser indicates FAULT upon startup.

SHG temperature is out of range. Leave laser plugged in for ~10 minutes.

• Laser has low or no output.

Pump diode needs to be replaced. Contact Sigma for service.

Transceiver

• Transmitted beam shape or quality degraded.

Contact Sigma for service. Do not use MPL.

• Detector failure.

Follow detector replacement procedure if a spare is available or Contact Sigma for service.

Software errors

• A/D conversion errors on screen.

Run National Instruments explorer. Refresh device listing Verify that DAQPad 6020e is listed as Device 1. Contact Sigma for service if problem persists.

Verify that the laser sync trigger is connected to SYNC on the data system, and the Q-switch is operational.

Contacting Sigma for Service

Sigma Space Corporation

4801 Forbes Boulevard

Lanham, MD 20706

Tel. 301-552-6300

Fax. 301-577-9466

http://www.sigmaspace.com/