Mira/RegA/OPA Daily Operation and Troubleshooting Guide

COHERENT
5100 Patrick Henry Drive
Santa Clara, CA 95054

Technical Support

In the US:

Should you experience any difficulties with your laser or need any technical information, please visit our web site **www.Coherent.com**. Additional support can be obtained by contacting our Technical Support Hotline at 800-367-7890 (408-764-4557 outside the U.S.) or E-mail (clg.tech.services@Coherent.com). Telephone coverage is available Monday through Friday (except U.S. holidays and company shutdowns).

If you call outside our office hours, your call will be taken by our answering system and will be returned when the office reopens.

If there are technical difficulties with your laser that cannot be resolved by support mechanisms outlined above, please E-mail or telephone Coherent Technical Support with a description of the problem and the corrective steps attempted. When communicating with our Technical Support Department, via the web or telephone, the model and Laser Head serial number of your laser system will be required by the Support Engineer responding to your request.

Outside the U.S.:

If you are located outside the U.S. visit our web site for technical assistance or contact, by phone, our local Service Representative. Representative phone numbers and addresses can be found on the Coherent web site, **www.Coherent.com**.

Coherent provides telephone and web technical assistance as a service to its customers and assumes no liability thereby for any injury or damage that may occur contemporaneous with such services. These support services do not affect, under any circumstances, the terms of any warranty agreement between Coherent and the buyer. Operation of any Coherent laser with any of its interlocks defeated is always at the operator's own risk.

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Preface

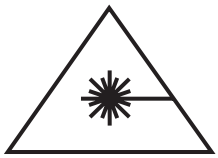
This daily operation and troubleshooting guide is intended for Coherent Ultrafast laser system operators. Such systems could include up to all the following laser components:

- Optical Parametric Amplifier (OPA)
- Regenerative Amplifier (RegA)
- Mira or Vitesse oscillator
- Each respective Verdi pumps

By using this guide, it is assumed that:

- The operator has received proper training and has read the operator manual of each laser component.
- The operator has previously operated the system for which this guide will be used.
- The operator is familiar with the terminology and abbreviations used in each operator manual.
- The Ultrafast system is pumped using the Coherent Verdi series lasers.

Read this manual carefully before operating the laser for the first time. Special attention should be given to the material in Chapter One: Laser Safety, that describes the safety features built into the Laser.



Use of controls or adjustments or performance of procedures other than those specified in this manual may result in hazardous radiation exposure.

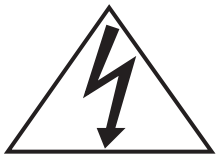
U.S. Export Control Laws Compliance

It is the policy of Coherent to comply strictly with U.S. export control laws.

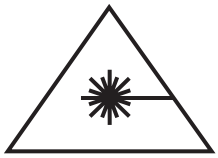
Export and re-export of lasers manufactured by Coherent are subject to U.S. Export Administration Regulations, which are administered by the Commerce Department. In addition, shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations.

The applicable restrictions vary depending on the specific product involved and its destination. In some cases, U.S. law requires that U.S. Government approval be obtained prior to resale, export or re-export of certain articles. When there is uncertainty about the obligations imposed by U.S. law, clarification should be obtained from Coherent or an appropriate U.S. Government agency.

Symbols Used in This Document



This symbol is intended to alert the operator to the presence of dangerous voltage within the product's enclosure that may be of sufficient magnitude to constitute a risk of electric shock and to indicate possible risk of equipment damage.



This symbol is intended to alert the operator to the danger of exposure to hazardous visible and invisible laser radiation.

This symbol is intended to emphasize the presence of important operating and maintenance instructions.

This symbol is intended to alert the operator to the danger of electrostatic discharge (ESD) susceptibility.

Reference and Contact Information

This guide is only a quick troubleshooting guide for daily operations. Should you need further details and instructions at any stage of the troubleshooting process, refer to the operator's manual corresponding to the chart you are working on and refer to the page indicated on the top right corner of each flow box.

Table-1 lists the part numbers of the Coherent Operator Manuals. Note that these numbers are current at the time of this printing and may be subject to change without notice.

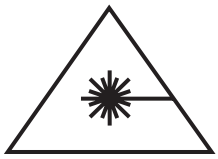
Table -1. Part Numbers of Coherent Operator Manuals

LASER	OPERATOR'S MANUAL PART NUMBER
PUMP	
Verdi V-8/V-10	0174-929-00
Verdi V-2/V-5/V-6	0171-750-00
Verdi V-18	1065343
Verdi OEM	0178-048-00
SEED	
Mira 900-F	1013390
Vitesse	0172-330-00
Vitesse Duo	1072485
AMPLIFIER	
RegA 9000	0165-083-00
RegA 9050	0175-008-99
OPA	
OPA 9400	0167-570-00
OPA 9800	1059970

CHAPTER ONE: LASER SAFETY

Optical Safety

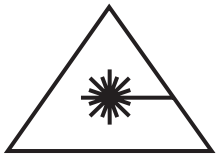
Because of its special properties, laser light poses safety hazards not associated with light from conventional sources. The safe use of lasers requires that all laser users—and everyone else near the laser system—are aware of the dangers involved. The safe use of the laser depends upon the user becoming familiar with the instrument and the properties of intense and coherent beams of light.



Direct eye contact with the output beam from the laser will cause serious damage and possible blindness.

Laser beams can ignite volatile substances such as alcohol, gasoline, ether and other solvents, and can damage light-sensitive elements in video cameras, photomultipliers and photodiodes. Reflected beams may also cause damage. For these reasons, the user is advised to follow the precautions below.

1. Observe all safety precautions in the operator's manual.
2. Exercise extreme caution when using solvents in the area of the laser.
3. Limit access to the laser to qualified users who are familiar with laser safety practices and who are aware of the dangers involved.
4. Never look directly into the laser light source or at scattered laser light from any reflective surface. Never sight down the beam into the source.
5. Maintain experimental setups at low heights to prevent inadvertent beam-eye encounter at eye level.



Laser safety glasses can present a hazard as well as a benefit while they protect the eye from potentially damaging exposure; they block light at the laser wavelengths, that prevents the operator from seeing the beam. Therefore, use extreme caution even when using safety glasses.

6. As a precaution against accidental exposure to the output beam or its reflection, those using the system should wear laser safety glasses as required by the wavelength being generated.
7. Avoid direct exposure to the laser light. The intensity of the beam can easily cause flesh burns or ignite clothing.
8. Use the laser in an enclosed room. Laser light will remain collimated over long distances and therefore presents a potential hazard if not confined.
9. Post warning signs in the area of the laser beam to alert those present.
10. Advise all those using the laser of these precautions. It is good practice to operate the laser in a room with controlled and restricted access.

Electrical Safety

The Mira/RegA/OPA/Vitesse use AC and DC voltages in the laser head and controller. All units are designed to be operated with protective covers in place. Certain procedures in this manual require removal of the protective covers. These procedures are normally used by a qualified trained service personnel. Safety information contained in the procedures must be strictly observed by anyone using the procedures.

Pump Source

Observe all safety precautions associated with the pump laser. Refer to the pump laser operator's manual for additional safety precautions.

CDRH Compliance

The following safety features incorporated in the laser conform to United States Government requirements 21 CFR Subchapter J as administered by the Center for Devices and Radiological Health (CDRH).

Protective Housing

Mira/RegA/OPA/Vitesse heads are enclosed in a protective housing that prevents human access in excess of the limits of class one radiation as specified in the Federal Register, July 31, 1975, Part II, Section 1040.10 (f) (1) and Table 1-A except for the output beam which is class 4.

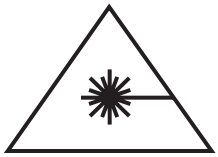
Hazardous Radiation Exposure

Use of controls or adjustments or performance of procedures other than those specified in the operator's manual may result in hazardous radiation exposure.

When the pumping beam of the Mira/RegA/OPA/Vitesse pump source is allowed to impinge on the titanium:sapphire crystal, both laser and collateral radiation are produced. The laser beam is emitted from the laser aperture which is clearly labeled:

AVOID EXPOSURE
VISIBLE AND INVISIBLE LASER RADIATION
IS EMITTED FROM THIS APERTURE.

Mira/RegA/OPA/Vitesse systems are designed to be used with the covers in position and these covers shield the operator from all collateral radiation. During initial alignment and maintenance operations, such as mirror alignment, it will be necessary to remove the covers. The covers are not interlocked with the circuitry of the pumping laser, but a label provides a warning about exposure to the radiation.



Operation of the Mira/RegA/OPA/Vitesse with covers removed will allow access to hazardous visible and invisible radiation. The housings should only be opened for the purposes of maintenance and service by trained personnel cognizant of the hazards involved. Extreme caution must be observed in operating the Mira/RegA/OPA/Vitesse with the cover removed. There are high- powered reflections that may exit at unpredictable angles from the Mira/RegA/OPA/Vitesse heads. These beams have sufficient energy density to cause permanent eye damage or blindness.

The Center for Devices and Radiological Health regulations apply only within the United States.

CDRH Compliance

1. Effective August 2, 1976, Coherent lasers are certified to comply with the Federal Regulations (21 CFR Subchapter J) as administered by the Center for Devices and Radiological Health.
2. The Mira/RegA/OPA/Vitesse does not include an integral power source; it utilizes the output beam of the pump laser to produce a coherent light output.

CHAPTER TWO: GENERAL CONNECTIONS

The following details the interconnects for a typical UF laser system. Refer to the sub-components operators manual for more detail or if you have slightly different system sub-components.

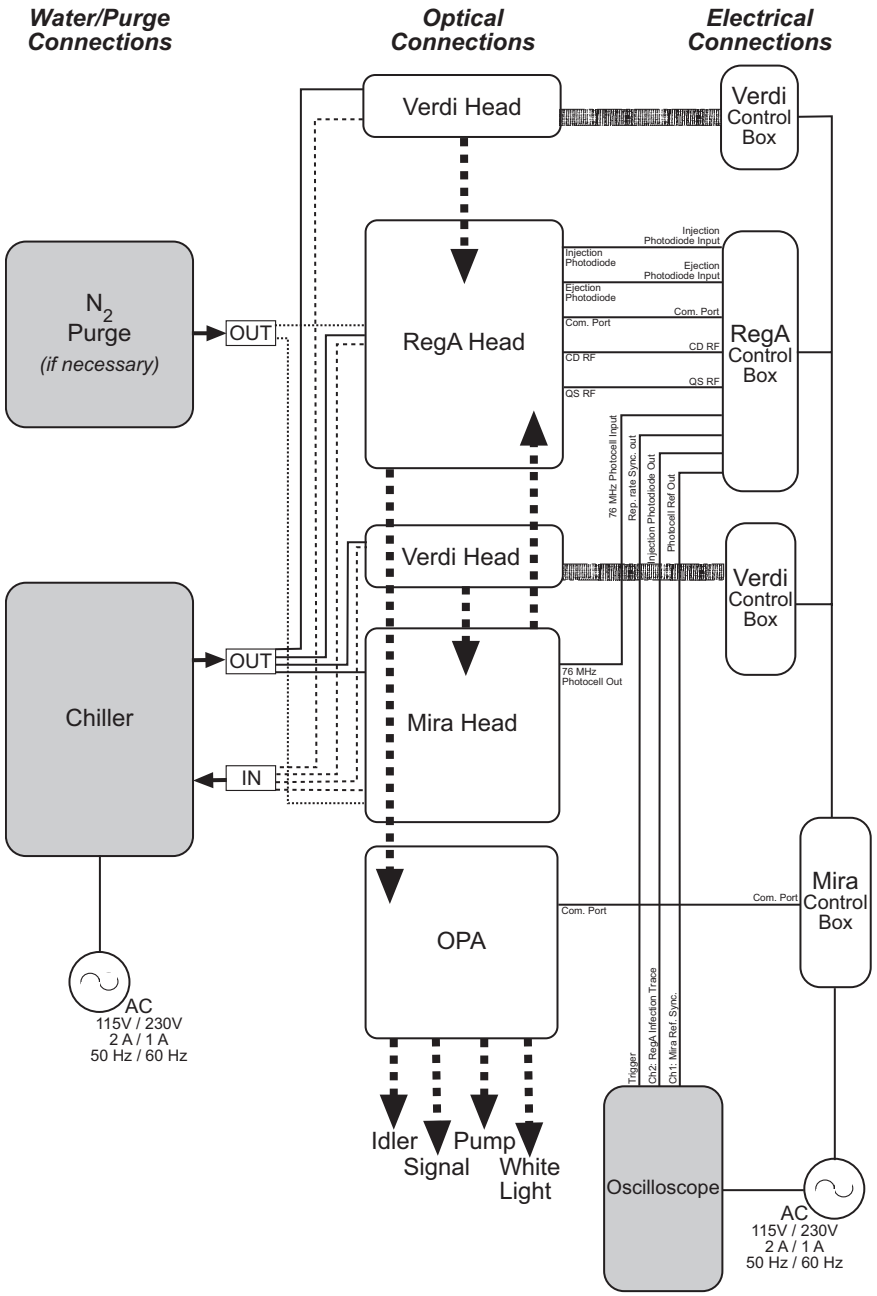


Figure 2-1. Coherent Ultrafast Laser System General Connections Layout

CHAPTER THREE: OPERATION

Introduction

This chapter details the procedure to turn on a Verdi/Mira/RegA/OPA ultrafast (UF) system. Refer to the sub-components operators manual for more detail or if you have slightly different system sub-components.

Turn-On Procedure

To keep the Ultrafast laser system optimized, Coherent recommends following the general turn-on procedure in the order indicated in Table 3-1.

Table 3-1. Turn-On Procedures

INSTRUCTIONS	VALUES AT INSTALLATION
Safety: Water/Power Supply	
Turn laser warning sign ON	
Wear appropriate safety glasses	
Turn Mira and RegA controllers and any diagnostic equipment ON	
Turn N_2 purge gas ON if necessary	N_2 flow rate:_____
Turn chiller water ON and wait for the temperature to stabilize	Temperature: _____, ± _____°C
Verdi (applies for both Mira and RegA pumps)	
Turn front panel keyswitch to ON	
Using the main menu, set proper pump power	
Wait five minutes	
Using "servo status" menu, record Verdi output power[1]	Verdi output power: _____, _____ W
Using "Diode parameters" menu, record diode currents[1]	Diode #1 current: _____, _____ A Diode #2 current: _____, _____ A
Using "Diode parameters" menu, record diodes' hours[1]	Diode #1 hours: _____, _____ H Diode #2 hours: _____, _____ H
Mira	

Table 3-1. Turn-On Procedures (Continued)

INSTRUCTIONS	VALUES AT INSTALLATION
Flip controller toggle switch to "Modelock"	
Record output power and pulsewidth[1]	Output power @ 800 nm: _____ W Pulsewidth @ 800 nm: _____ fs
RegA	
Recall desired setting (Use "recall operation state" menu on the controller) or use default settings	
Optimize build-up and ejection trace by adjusting the Ejection and Injection phases and delays (may also use QSW delay and width)[1]	
Optimize output power and build-up using pump controls (P2)	
Save setting (use "Save operation state" menu on controller)[1]	QS row: _____, _____, _____ Injection row: _____, _____, _____ Injection row: _____, _____, _____ CD row: _____, _____, _____ Round trips: _____
Record RegA output power[1]	CW cavity power: _____W Pseudo-CW power: _____W Seeded CD power _____W RegA output power: _____W
Record RegA autocorrelated pulse width[1]	RegA pulse width: _____fs
OPA 9400	
Record second harmonic generation light (power meter after M3)[1]	SHG power: _____mW SHG control setting: _____mm
Rotate the OPA crystal for the desired wavelength	OPA mic setting _____ for _____nm
Optimize delays D1 and D2 for maximum output power	D1 setting: _____mm D2 setting: _____mm
Record OPA output power (signal or idler)[1]	OPA power @ _____nm: _____mW OPA power @ _____nm: _____mW OPA power @ _____nm: _____mW
1. Optional steps	

Should you experience any problems during the above turn-on and optimization procedures, proceed to the troubleshooting flowcharts.

Shut-Down Procedure

To shut the system down for a short-term period of time (less than 10 days), follow these steps:

1. Close all Verdi pump shutters.
2. Turn the keyswitch on each Verdi OFF (standby mode). **Do not** turn the power switch located on the back of the Verdi control box off.
3. Turn the Mira and RegA control boxes and all diagnostic equipment OFF.
4. Turn the water cooling system (chiller) off.
5. Turn the N_2 purge off (if it was engaged).
6. Turn the laser warning sign OFF if no other lasers are in use.

Refer to the Verdi Operator manual for the long-term shutdown procedure if you plan to not operate the laser for longer than 10 days.

CHAPTER FOUR: TROUBLESHOOTING FLOWCHARTS AND OPTICAL LAYOUTS

Introduction

This section is structured to give a logical and efficient way of troubleshooting a Coherent Ultrafast laser system. It is designed specifically for a two-Verdi-pumped Mira 900/RegA9000/OPA9400 laser system, but most of the troubleshooting techniques can be easily applied to many of the Coherent UF laser systems in this general family. This includes systems with a Vitesse or a Mira Seed, systems with a Vitesse Duo, systems with a single Verdi pump, systems with a RegA 9050, or systems with a 9450, 9800 or 9850 OPA. Refer to the sub-components' operators manual for more details.

This section consists of two major components:

- A troubleshooting flowchart for each laser sub-system.
- Details related to each flowchart (located immediately after the corresponding flowchart).

Start the troubleshooting process by using the flowchart corresponding to the last component in your system. For example, in the case of a complete OPA-RegA-Mira-Verdi system, troubleshoot the system by starting with the OPA flowchart. References and links to the appropriate manual are provided as needed on each flowchart.

Each flowchart uses logical test questions that will help you to easily navigate through the chart. On the flowcharts, each logical step is illustrated by a flow box. In each of these flow boxes, you will find the following information (refer to Table 4-1):

- Flowchart box number
- Operator's manual reference page (if applicable)
- Action to be taken at this troubleshooting step
- Flow question
- Logical flow
- Possible answer to flow question

Immediately after each flowchart, you will find bulleted details related to each flow box. Refer to the appropriate details by seeking the details label number associated with a given flow box.

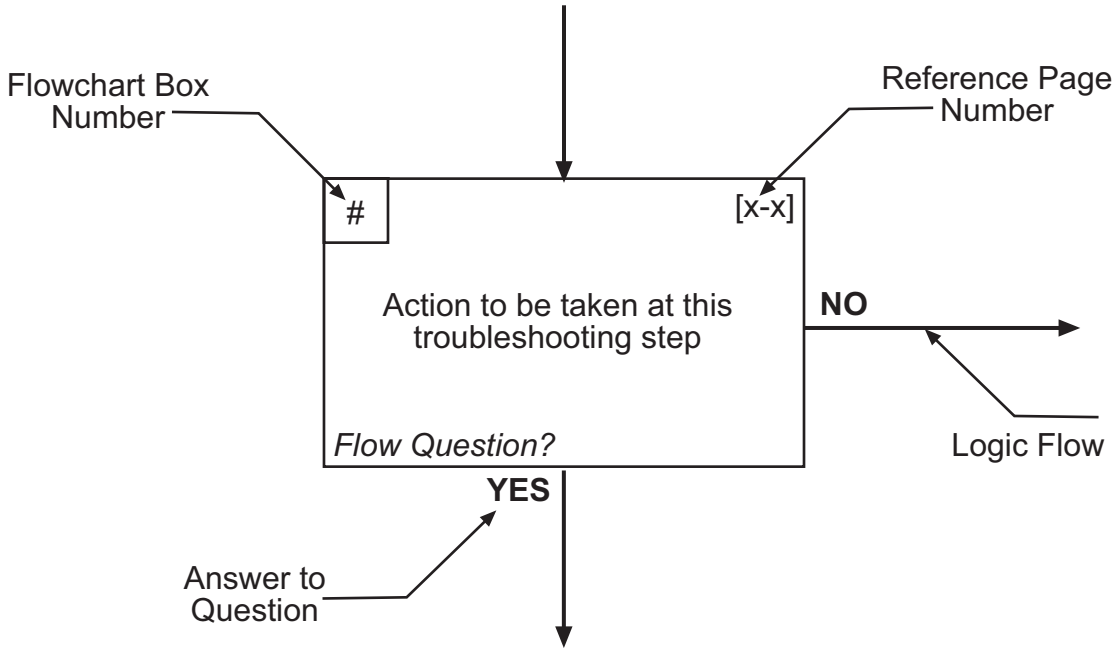


Figure 4-1. Flow Box Legend

OPA 9400

Materials Needed

- Laser safety glasses (> 480 to 800 nm)
- Power meter (0 to 2 W)
- Autocorrelator
- Spectrometer

Optical Layout

General optical layout for the OPA 9400 platform is shown in Figure 4-2.

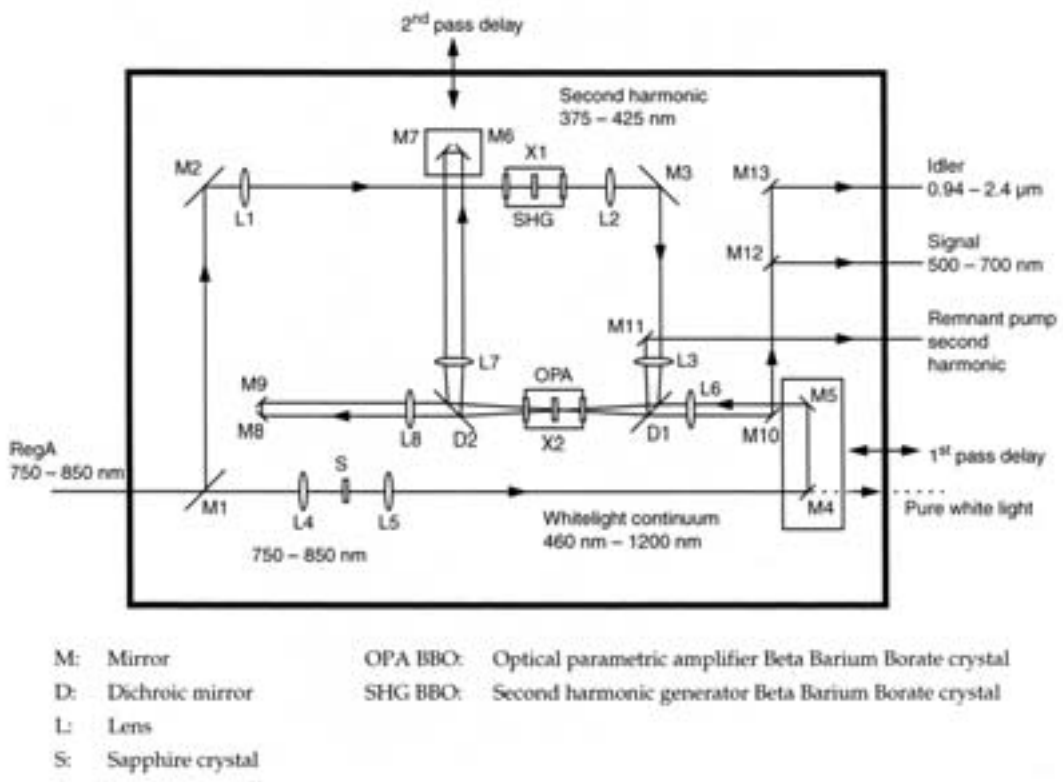


Figure 4-2. Optical Layout, OPA 9400 Platform

OPA 9400 Flow Boxes Instructions

OPA 9400 troubleshooting flowchart

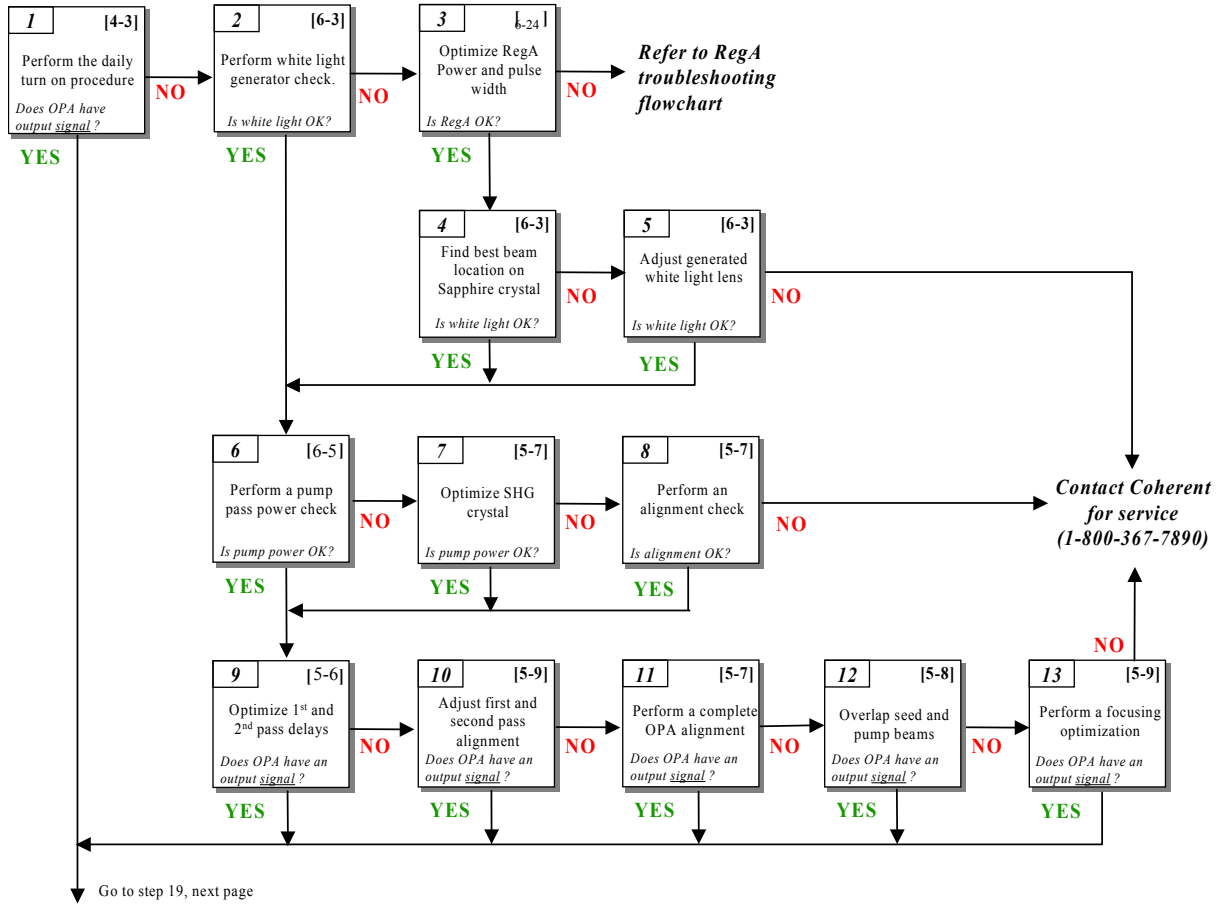


Figure 4-3. OPA 9400 Flowchart 1

System Initialization

1. Perform the daily turn on procedure [4-3].
   a.) Turn cooling water on (all if more than one).
   b.) Turn Verdi pump keys to ON position (Mira and RegA).
   c.) Open shutters.
   d.) Verify Verdi pumps powers.
   e.) Peak Mira CW power (using P2, M7).
   f.) Verify the Mira modelocking using spectrometer.
   g.) Peak RegA power (using P2).

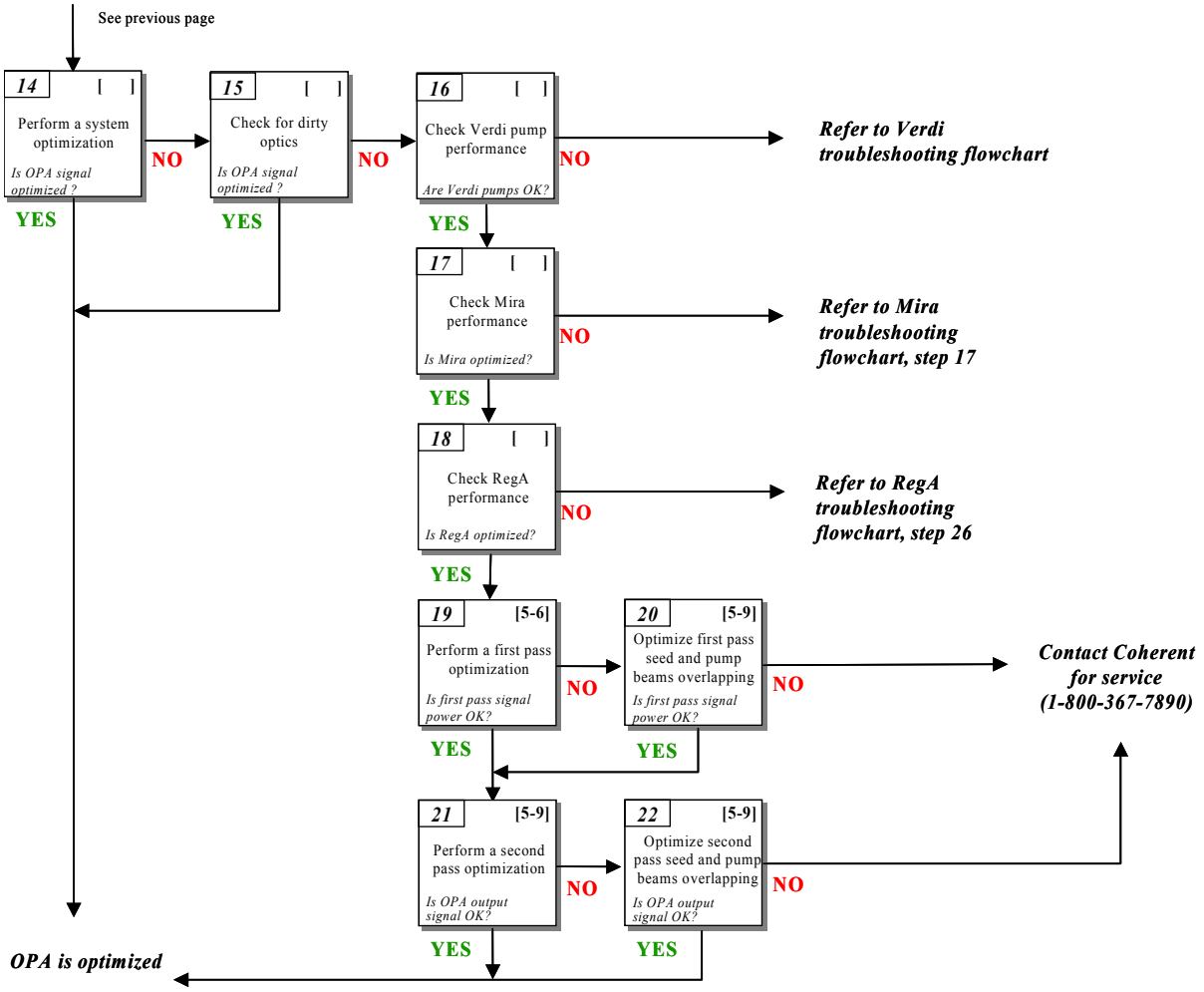


Figure 4-4. OPA 9400 Flowchart 2

h.) Optimize RegA injection trace (Injection/Ejection delays and phases, P2, IM2).

i.) Set OPA crystal settings to approximately 610 to 620 nm.

j.) Check OPA output signal power.

2. Perform white light generator check [6-3].

a.) Place a white card before M4.

b.) Unblock RegA beam.

c.) Check that white light is visible on the card.

d.) Place a power meter before M4.

e.) Ensure all optics are clean; clean if necessary.

3. Optimize RegA power and pulse width.
    a.) Adjust CD ejection delays and phase.
    b.) Adjust CD injection delays and phase.
    c.) Adjust QS width if necessary.
    d.) Fine tune IM2 vertically and horizontally.
    e.) Fine tune Mira pump control P2.
    f.) Fine tune RegA pump control P2.
    g.) Set the autocorrelator after RegA.
    h.) Tune Mira BP2 control to optimize pulse width.
    i.) Tune RegA DG control to optimize pulse width.
4. Find best beam location on Sapphire crystal [6-3].
    a.) Translate vertical and horizontal of S.
    b.) Ensure that there is no clipping near crystal edges.
5. Adjust generated white light beam profile [6-3].
    a.) Adjust L4 *z* position to get white light on a card before M4.
    b.) Fine tune L5 to collimate white light beam.
6. Perform pump pass power check [5-6].
    a.) Place power meter after M3.
7. Optimize SHG crystal (X1)[5-7].
    a.) Tune LBO control (X1) to get maximum pump power after M3.
8. Perform an alignment check [5-7].
    a.) Verify that the beam is NOT clipped on M2, M3, L2, L1, L3, and D1.
    b.) Beam goes through X1 (SHG) (either in the center or best spot).
9. Optimize first and second pass delays.
    a.) Record delay 1 and delay 2 settings.
    b.) Block second pass (before M6).
    c.) Fine tune delay 1 over the range until the best signal is achieved (use eyes or photodiode).
    d.) Unblock the second pass.

e.) Fine tune delay 2 over the range until signal is best amplified.

10. Adjust first and second pass alignment [5-9].

    a.) Block second pass (before M6).

    b.) Fine tune M3 or D1 vertically until the best signal is achieved on the white card or photodiode.

    c.) Fine tune M3 or D1 horizontally until the best signal is achieved on the white card or photodiode.

    d.) Unblock second pass.

    e.) Fine tune D2 or M7 vertically until the best amplified signal is on the card or photodiode.

    f.) Fine tune D2 or M7 horizontally until the best amplified signal is on the card or photodiode.

11. Complete OPA Alignment [5-7].

SHG Optimization

a.) Place power meter after M3.

b.) Loosen L1 and move its Z position to find maximum power.

c.) Make sure beam goes through X1 and does not clip on any optics

d.) Adjust L2 Z position to collimate the blue pump beam (use near and far field spot sizes).

First and Second Passes Seed

a.) Remove X2. Place all alignment apertures at their respective locations.

b.) Ensure beam not clipped at M1. Center beam on M2 using M1.

c.) Block beam before M2.

d.) Center on L4. Adjust L4 to obtain white light on white card placed before M4.

e.) Center beam on white light generator (S), or best spot.

f.) Adjust horizontal and vertical of L5 to center the beam on M4.

g.) Adjust the Z position of L5 to collimate white light beam (look near and far field).

h.) Center on M5 using M4.

i.) Maximize power after M5 aperture using M4 (use either power meter and routing mirror or white card).

j.) Maximize power after X2 aperture using M5.

k.) Iterate 12 and 13 until both power checks are maximized simultaneously.

l.) Verify that the beam is approximately centered on aperture before M8 (if not, walk beam using M4, M5).

m.) Maximize power after aperture after M9 using M8.

n.) Maximize power after X2 aperture using M9.

o.) Iterate 16 and 17 until both power checks are maximized simultaneously.

First and Second Passes Pump

a.) Block seed after M1.

b.) Unblock pump after M1.

c.) Center on M3 using M2.

d.) Verify that beam is not clipped by X1 (translate X1 to get maximum power after M3).

e.) Maximize power after M3 aperture using M2 (use either power meter and routing mirror or white card).

f.) Maximize power after X2 aperture using M3.

g.) Iterate 22 and 23 until both power checks are maximized simultaneously.

h.) Maximize power after M7 aperture using D2.

i.) Maximize power after X2 aperture using.

j.) Iterate 25 and 26 until both power checks are maximized simultaneously.

k.) IF the beam is not centered on all M6, M7 and X2 apertures simultaneously, walk the beam using M6 and M7, and repeat 27.

l.) Remove all apertures, and put X2 back on.

12. Overlapping Seed and Pump Beams [5-8]

First Passes Overlap

a.) Block beam before M6.

b.) Tap off beam after L8. Direct beam on a white card about half a meter (about 1.5 feet) away.

c.) Notice the white light beam center position.

d.) Block white light beam before L4.

e.) Adjust M3 to overlap blue pump beam spot with white beam spot.

f.) Unblock beam before L4.

g.) Tap off beam after L8. Direct beam on a white card approximately two to three meters (about 6 to 9 feet) away.

h.) Notice the white light beam center position.

i.) Block white light beam before L4.

j.) Adjust M4 to overlap blue pump beam spot with white beam spot.

k.) Unblock beam before L4.

l.) Iterate 2 to 11 until blue and white spots overlap at both near and far field screen locations.

m.) Remove tap off mirror after L8.

Second Passes Overlap

a.) Place a white screen about half a meter (about 1.5 feet) away from OPA output panel (signal output).

b.) Notice the white light beam center position.

c.) Block white light beam before L4

d.) Adjust D2 to overlap blue pump beam spot with white beam spot.

e.) Unblock beam before L4.

f.) Place a white screen approximately two to three meters (about 6 to 9 feet) away from OPA output panel (signal output).

g.) Notice the white light beam center position.

h.) Block white light beam before L4

i.) Adjust M7 to overlap blue pump beam spot with white beam spot.

j.) Unblock beam before L4.

k.) Iterate 14 to 23 until blue and white spots overlap at both near and far field screen locations.

13. Focusing Optimization [5-9]

First Pass Focusing

a.) Remove X2.

b.) Screw in X2 aperture.

c.) Block beam before and M2.

d.) Measure power after X2 aperture.

e.) Move L6 as close as possible to M5.

f.) Move Z position of L6 slightly towards X2.

g.) Repeat d) to f) until a position is located at which power is maximized.

h.) Unblock beam before M2.

i.) Block white light before L4.

j.) Measure power after X2 aperture.

k.) Move L3 as close as possible to M3.

l.) Move Z position of L3 slightly towards D1.

m.) Repeat j) to l) until a position is located at which power is maximized.

Second Pass Focusing

a.) Block beam before and M6.

b.) Measure power after X2 aperture (second pass on D1: do not block the first pass).

c.) Move L8 as close as possible to M9.

d.) Move Z position of L8 slightly towards X2.

e.) Repeat b) to d) until a position is located at which power is maximized.

f.) Unblock beam before M6.

g.) Block white light before L4.

h.) Measure power after X2 aperture (second pass on D1: do not block first pass).

i.) Move L7 as close as possible to M6.

j.) Move Z position of L7 slightly towards D2.

k.) Repeat h) to j) until a position is located at which power is maximized.

l.) Unblock white light.

m.) Remove X2 aperture and put X2 back on.

System Optimization (OPA Output Signal Achieved)

14. Perform a system optimization.
    a.) Verify that all Verdi powers are OK.
    b.) Optimize the RegA ejection trace by fine-tuning IM2, P2, and the ejection and injection delays and phases.
    c.) Peak Mira power (using Mira control) by using P2, M7 and the slit.
    d.) Fine tune Mira BP2 to optimize pulse width (best OPA power).
15. Check for dirty optics; clean if necessary.
    a.) Block beam while cleaning optics.
    b.) DO NOT clean X1 and X2.
16. Check Verdi pump performances.
    a.) Set Verdi power to proper levels.
    b.) Measure output power from Verdi (RegA's and Mira's).
    c.) Monitor power over few minutes for stability.
    d.) Verify that cooling water is on.
17. Check Mira performances.
    a.) Peak Mira power using P2, M7, and the slit.
    b.) Verify that there is no CW nor Q-switching leak.
    c.) Measure the Mira output power.
    d.) Measure Mira output spectrum.
18. Check RegA performances.
    a.) Peak P2 for best RegA output power.
    b.) Measure RegA pulse width (optimize by fine tuning DG control).
    c.) Measure RegA output power (optimize by fine tuning M8 and M0/M1).
    d.) Check injection trace (optimize delays and phases).
19. Perform a first pass optimization. [5-6]
    a.) Block the beam before M6.
    b.) Set a power meter in front of OPA signal output port.
    c.) Fine-tune delay 1 for best signal power.
    d.) Fine-tune X1 (SHG) control for best signal power.

e.) Fine-tune both vertical and horizontal of M3 for best signal power.

20. Optimize first pass seed and pump beams overlapping. [5-9]
    a.) Refer to OPA step 17 in this manual.
    b.) Repeat OPA step 24 in this manual.
21. Perform a second pass optimization. [5-9]
    a.) Unblock the beam before M6.
    b.) Set a power meter in front of OPA signal output port.
    c.) Fine-tune delay 2 for best signal power.
    d.) Fine-tune both vertical and horizontal of D2 for best signal power.
22. Optimize second pass seed and pump beams overlapping [5-9]
    a.) Refer to OPA step 17 in this manual.
    b.) Repeat OPA step 26 in this manual.

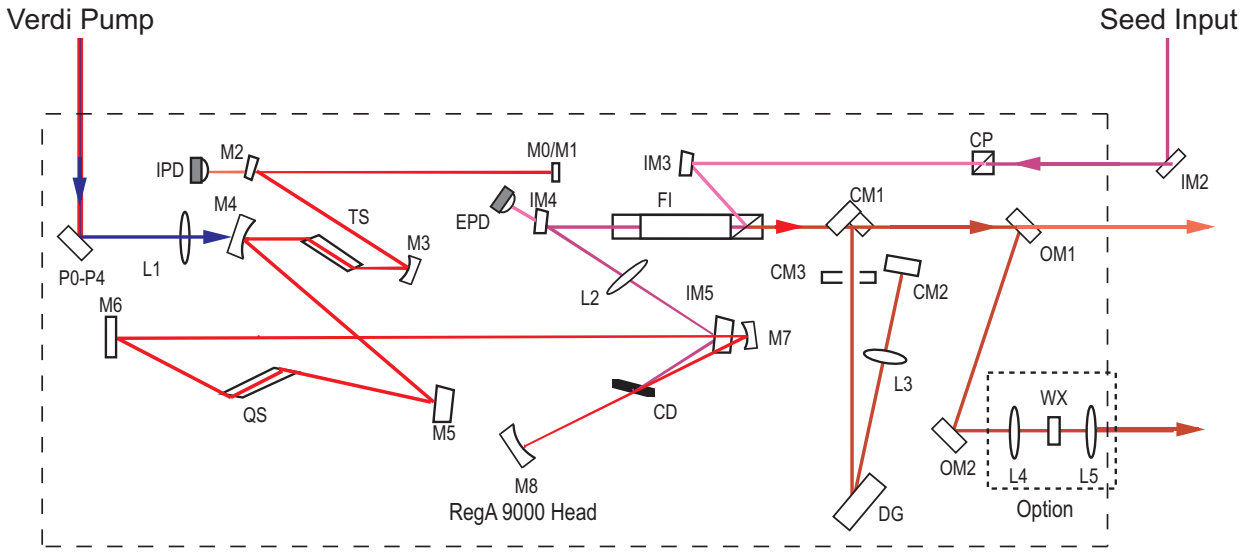
RegA 9000

Prerequisites:

- Laser safety glasses (~ 532nm, ~ 800 nm)
- Power meter (0 to 5 W)
- 350 MHz oscilloscope
- IR viewer
- Autocorrelator

Optical Layout

General optical layout for the RegA 9000 platform is shown in Figure 4-5.



IPD:	Injection Photodiode	M0-M8:	Cavity Optics
EPD:	Ejection Photodiode	IM1-IM5:	Injection Optics
QS:	Q-Switch	CM1-CM3:	Compressor Optics
CD:	Cavity Dumper	WM1-WM2:	Whitelight Optics
FI:	Faraday Isolator	L0-L5:	Lenses
CP:	Cube Polarizer	P0-P4:	Pump Optics
DG:	Diffraction Grating	TS	Ti:Sapphire Crystal
WX:	White Light Crystal		

Figure 4-5. Optical Layout, RegA 9000 Platform

RegA 9000 Flow Boxes Instructions

RegA 9000 troubleshooting flowchart

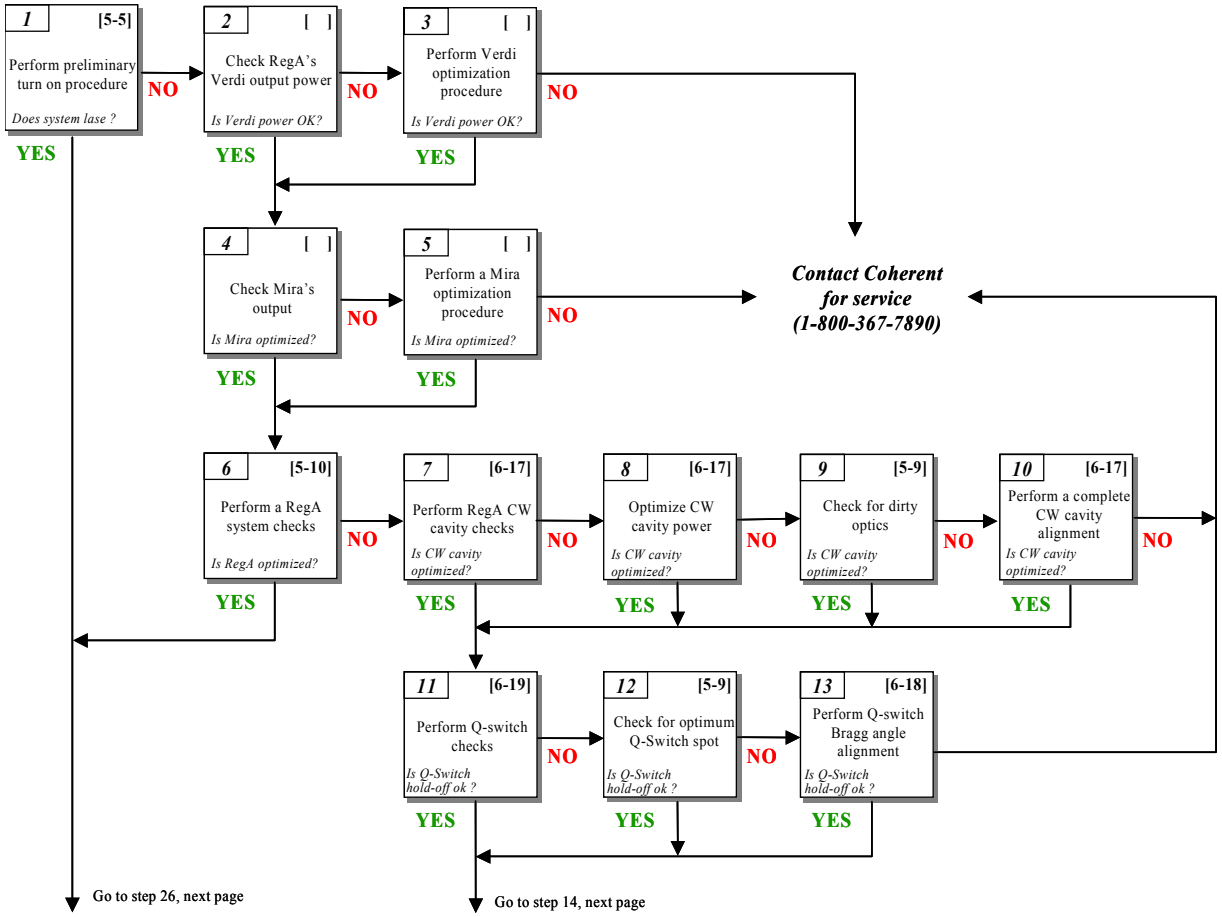


Figure 4-6. RegA 9000 Flowchart 1

System Initialization

1. Perform preliminary turn-on procedures [5-5].

   a.) Turn cooling water supply (and Nitrogen purge for > 870 nm) on.

   b.) Turn RegA pump Verdi on, warm up, set power, and open the shutter.

   c.) Turn Mira pump, and Mira controller on, and warm up.

   d.) Optimize Mira laser output (P2, slit, or M7). (Refer to Mira-F flowchart on page 4-22.

   e.) Turn RegA control box on (SERVOs OFF).

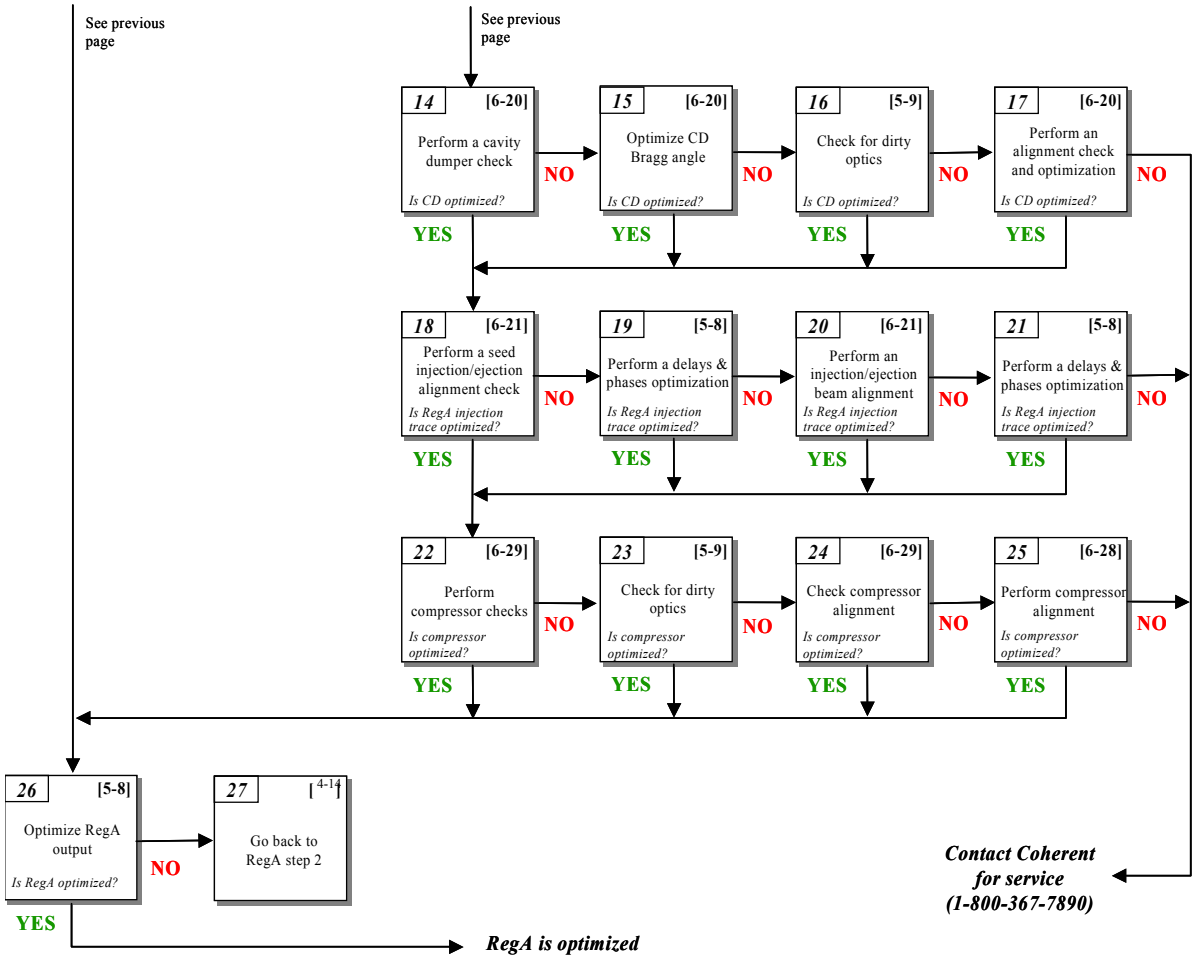


Figure 4-7. RegA 9000 Flowchart 2

f.) Plug "Photodiode reference out" and "Injection photodiode out" into the oscilloscope.

g.) Use "Rep. rate synch out" as trigger.

h.) Optimize RegA injection trace (Injection/Ejection delays and phases, P2, IM2), step h), page 4-5.

Pump Check

2. Check RegA's Verdi output power.

a.) Ensure that the Verdi controller key is turned on.

b.) Is the displayed Verdi pump power at actual output power? If not, contact Coherent Service.

c.) Is the pump transverse mode profile at TEM_{00}? If not, contact Coherent Service.

d.) Does the pump beam hit the input pump mirror in the RegA?

e.) Is the pump approximately centered on P4?

3. Perform Verdi optimization procedure.

a.) Refer to Verdi flowchart.

Seed Check

4. Check Mira's output.

a.) Is Mira controller on?

b.) Is the output power OK?

c.) Is it modelocked WITHOUT CW component?

d.) Is the FWHM bandwidth at 10 nm?

e.) Is the pulse train stable at 76 MHz?

f.) Is the Mira transverse mode profile OK?

5. Perform Mira optimization procedure.

a.) Refer to Mira-F flowchart.

RegA Check and Optimization

6. Perform a RegA system check [5-10].

a.) Is the RegA controller on?

b.) Is the output power OK?

c.) Is the pulse length OK?

d.) Is the injection trace optimum (see figure 5-3 in the RegA 9000 Operator's Manual)?

7. Perform RegA CW cavity check [6-17].

a.) Select "Alignment submenu #1.

b.) Is CW power after M1 OK?

8. Optimize CW cavity power [6-17].

a.) Adjust M8 and M1.

b.) Peak P2.

c.) Optimize spot on QS and CD.

9. Check for dirty optics [5-9] and clean if necessary.

a.) Close RegA's Verdi shutter or block beam while cleaning optics.

b.) Check and clean:

- M1, M2
- M5, M6, M7
- M8, QS

10. Perform a complete CW cavity alignment [6-17].
    a.) Select Alignment menu #1 controller.
    b.) Ensure that the green beam centered on M2 (use M3), and M1 (use M2).
    c.) Use the alignment fixture to overlap beams (use alignment fixture), and M1.
    d.) Horizontally center fluorescence beam below top edge of M5.
    e.) Center on M6 (through QS, use alignment fixture).
    f.) Horizontally center, just above IM5.
    g.) Overlap fluorescence beams on alignment fixture before M6.
    h.) Fine tune M8, M1, P2, and seek for lasing.
11. Perform Q-switch checks [6-19].
    a.) Record power after M1.
    b.) Select alignment submenu # 2
    c.) Increase QS amplitude to approximately 70-80 counts
12. Check for optimum Q-switch spot [5-9].
    a.) Block beam while cleaning optics.
    b.) Clean both QS faces.
    c.) Beam goes through QS
    d.) Optimize beam path into QS for best power (QS vertical and horizontal translation)
13. Perform Q-switch Bragg angle alignment [6-18].
    a.) Set QS amplitude at 35 counts.
    b.) Peak cavity mirrors M8, M1.
    c.) Tune QS Bragg angle in one direction until CW power drops by about 50%
    d.) Re-peak cavity (M8, M1).
    e.) Repeat (c) and (d) until you cannot re-peak the cavity.

- IF e) cannot be achieved, repeat b) and c) in the opposite direction.

f.) Set QS amplitude about 10 counts.

g.) Repeat b) to e)

h.) Verify that when QS amplitude is at 70 counts, CW power is approximately 0.

14. Perform a cavity dumper check [6-20].

    a.) Select alignment submenu #4.

    b.) Set power meter after CM1 (use routing mirror).

    c.) Set CD amplitude at 100.

    d.) Check if far field output beams overlap (beam coming from CM1).

    e.) Check that power is approximately 300 mW.

15. Optimize CD Bragg angle [6-20].

    a.) Place white card before IM4.

    b.) Adjust CD Bragg angle knob (with CD amplified to 100) for best diffracted power on white card.

    c.) Re-peak cavity power (after M1).

    d.) Repeat a) and b) until max output power (after CM1) is achieved.

    e.) Adjust CD horizontal and vertical positions to peak power after CM1.

    f.) Adjust CD *z* position until the far field beams overlap.

16. Check for dirty optics [5-9] and clean if necessary.

    a.) Close shutter or block beam while cleaning optics

    b.) CD faces

    c.) IM5, IM4, CM1

    d.) FI prisms end faces

17. Perform an alignment checks and optimization [6-20].

    a.) Does the deflected beam hit below IM5 top edge?

    b.) Is the beam centered on IM4? (use IM5)

    c.) Is there clipping on FI? (if not, use IM4, IM5)

    d.) Is the center on “V” position on CM1? (use IM4)

    e.) No clipping on CM3? (use IM4, IM5)

f.) Perform a seed injection alignment check [6-21]

g.) Select Alignment submenu #5.

h.) Unblock and optimize the Mira beam.

i.) Look at "Injection photodiode out" on oscilloscope.

j.) Verify that power ejection at DG about 50% of CW power after M1 (when alignment menu #1).

18. Perform a delay and phase optimization [5-8].

    a.) Minimize injection rise time (adjust injection delays and phase).

    b.) Maximize the ejection power (adjust ejection delays and phase and QS width).

    c.) Iterate until optimum trace is obtained.

    d.) Ensure to minimize cavity round trips (< 25).

19. Perform an injection/ejection beam alignment [6-21].

    a.) Monitor trace on oscilloscope and power after CM1.

    b.) Block Mira output, and screw in the magnet screw on FI to allow leakage.

    c.) Walk beam (M6, M8) for deflected beam to hit below IM5 top edge.

    d.) Adjust IM5 to center beam on IM4 (use IM5).

    e.) Ensure that there is no clipping on FI. (use IM4, IM5)

    f.) Position beam on "V" position on CM1- Fig.6-6. (use IM4)

    g.) Center leaking beam on IM3. (use IM5)

    h.) Ensure no clipping on CM3. (use IM4, IM5).

    i.) Iterate a) to h) until optimized.

    j.) Place alignment fixture before CP.

    k.) Center red leaking beam on CP (horizontal) and on alignment fixture (vertical, use IM3).

    l.) Unblock Mira output.

    m.) Adjust IM1 to center Mira beam on alignment fixture.

    n.) Place alignment fixture after IM3.

    o.) Center alignment fixture on leaking red beam.

    p.) Adjust IM2 to center Mira beam on alignment fixture.

q.) Place alignment fixture before CP.

r.) Center it on leaking red beam.

s.) Iterate j) to o) until trace is optimized on oscilloscope.

t.) Unscrew the magnet screw on FI to stop leakage.

20. Perform a delay and phase optimization [5-8].

    a.) Monitor injection trace on oscilloscope and power after CM1.

    b.) Minimize injection rise time (adjust injection delays and phase).

    c.) Maximize the ejection power (adjust ejection delays and phase and QS width).

    d.) Iterate until optimum trace is achieved.

21. Perform compressor checks [6-29].

    a.) Exit all alignment menus.

    b.) Ensure that power at 75% power after CM1

    c.) Ensure that pulse length OK.

22. Check for dirty optics [5-9] and clean if necessary.

    a.) Close shutter or block beam while cleaning optics.

    b.) Check and clean the following optics:

    - CM1, CM3, CM2, L3.
    - WM1, WM2
    - L4, L5

    c.) Note: **Do Not** clean DG without contacting Coherent Service.

23. Check compressor alignment [6-29].

    a.) Ensure that there are 4 visible spots on DG as in Fig. 6-6 of the Operator's Manual.

    b.) Ensure that there is no clipping on CM3.

    c.) Ensure that there is no clipping on CM1.

    d.) Ensure that the beam is centered on WM1, WM2.

    e.) Optional: ensure that the beam is centered on L4, and L5.

24. Perform compressor alignment [6-28].

    a.) Set up the autocorrelator.

b.) Remove DG.

c.) Adjust CM1 so the beam hits DG above its pivot point.

d.) Put DG back on its mount.

e.) Rotate DG to center first order diffracted beam on CM2 (off center on L3).

f.) Adjust vertical and horizontal on CM1 to position first spot on DG (as shown in Figure 6-6 of the Operator's Manual).

g.) Adjust CM2: The second spot must be straight below the first spot on DG and below top edge on CM3.

h.) Adjust CM3: The third spot must be straight below the second spot on DG.

i.) Verify that the fourth spot is straight above the first spot on DG (adjust CM3).

j.) Verify that CM1 pickoff without clipping.

k.) Tilt horizontal of CM1 to obtain a diagonal spot alignment on DG.

l.) Align WM1 to center on WM2

m.) Optimize DG micrometer to minimize pulse width.

n.) Optimize L3 tilt and DG angle.

o.) Optimize ejection and injection delays and phases.

System Optimization

25. Optimize RegA output [5-8].

a.) Exit all alignment menus.

b.) Monitor RegA trace on the oscilloscope.

c.) Optimize ejection and injection delays and phases.

d.) Peak the pump control P2.

e.) Peak M8 and M1 if necessary.

f.) Optimize the pulse width (set autocorrelator) using DG control.

Mira 900-F

Materials Needed

- Laser safety glasses (at 532 nm, 700 to 1100 nm)
- Power meter (0 to 5 W)
- ≥ 350 MHz oscilloscope
- IR viewer
- Autocorrelator

Optical Layout

General optical layout for the Mira-900F platform is shown in Figure 4-8.

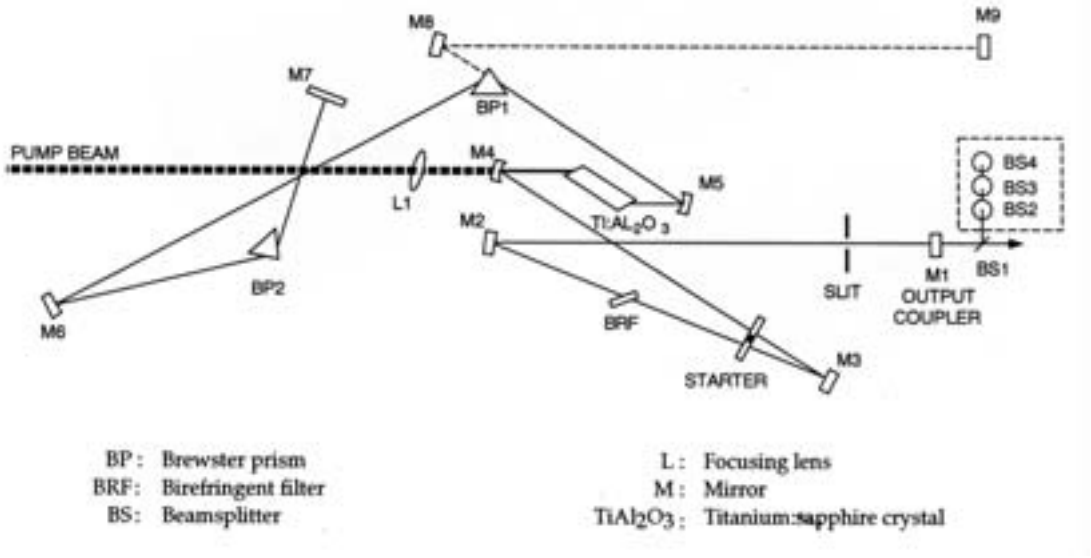


Figure 4-8. Optical Layout, Mira Platform

Mira 900-F Platform Flow Boxes Details

Mira 900-F troubleshooting flowchart

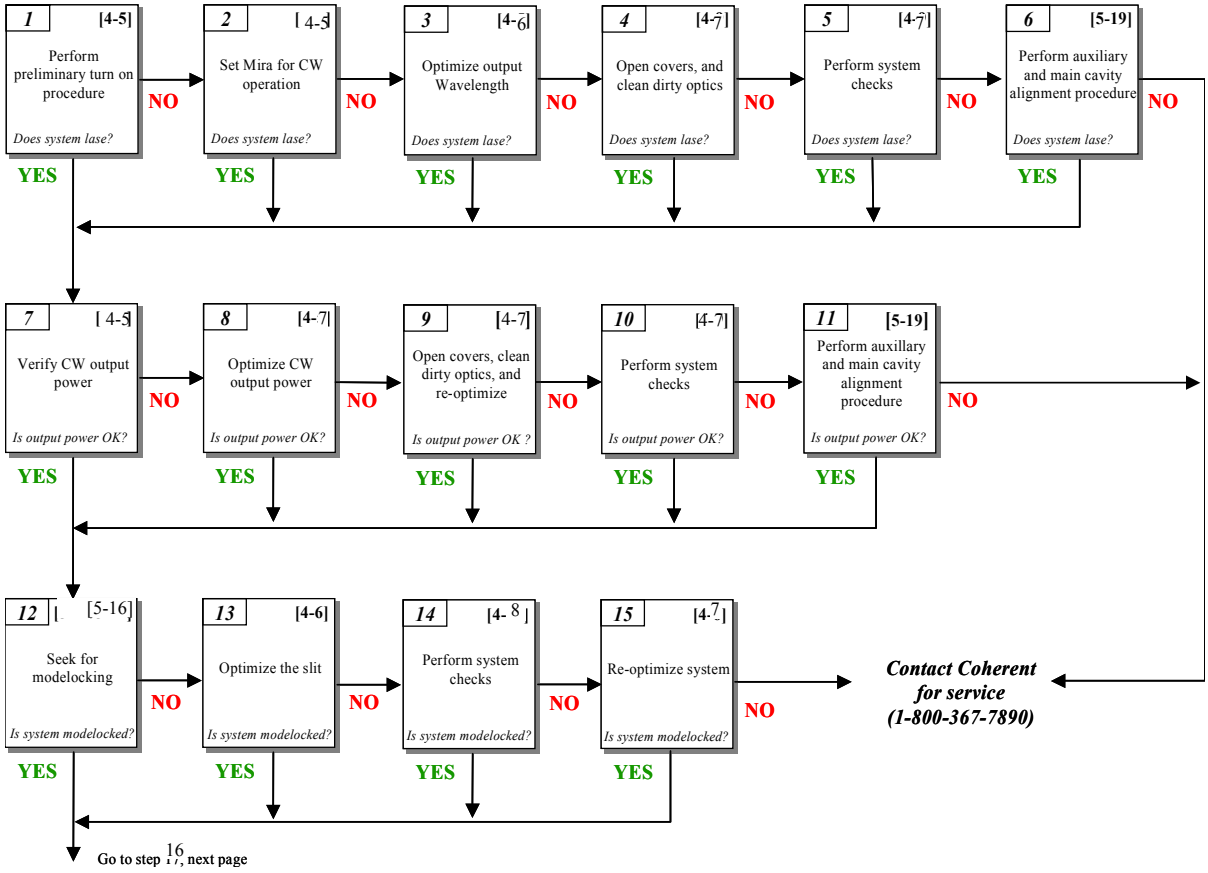


Figure 4-9. Mira Flowchart 1

System Initialization

1. Perform preliminary turn-on procedure [4-5].
   a.) Turn the water supply (and Nitrogen purge for wavelengths > 890 nm) on.
   b.) Turn the pump laser on, warm up, set power, and open shutter.
   c.) Turn the Mira controller on and select CW mode.
2. Set Mira for CW operation.
   a.) Center the slit (use the fluorescence).

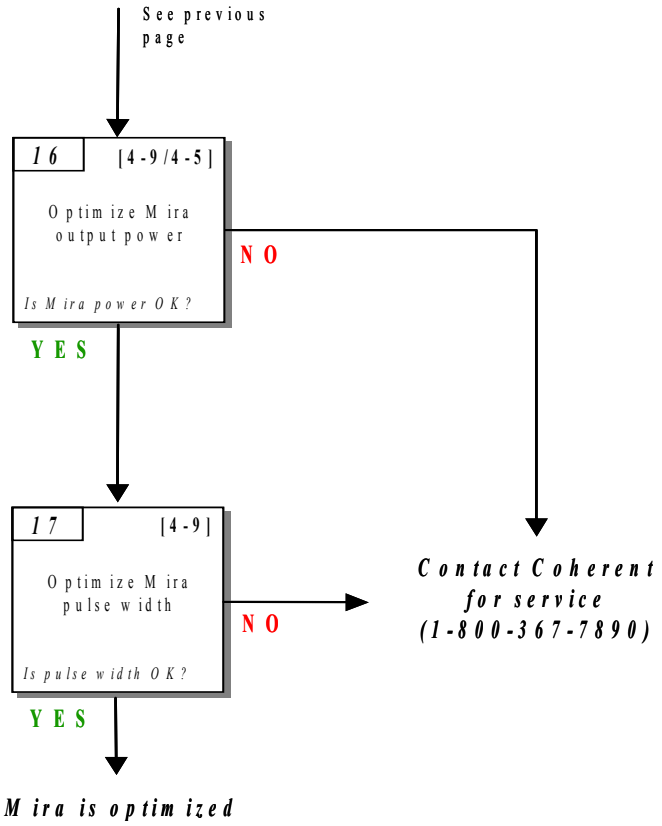


Figure 4-10. Mira Flowchart 2

b.) Ensure CW mode is selected on controller.

c.) Open the slit completely.

3. Optimize output wavelength [4-6].

   a.) Set the BRF to the peak of the wavelength tuning curve.

   b.) Adjust the prisms to accommodate the peak wavelength.

   - Or set the BRF to the 0th order.

4. Open the covers and clean dirty optics [4-7].

   a.) Close the Verdi shutter or block the beam while cleaning the optics.

   b.) Clean the optics: M1, M2, M3, M4, M5, M7, M8.

   c.) Clean the Ti:Sapphire end faces, BP1 and BP2 side faces.

5. Perform system checks [4-7].

   a.) Water cooling temperature and pressure OK? If not, refer to the chiller manual and check the plumbing.

b.) Is the displayed Verdi pump power at actual output power? If not, refer to the Verdi flowchart.

c.) Is the pump transverse mode profile at TEM_{00}? If not, contact Coherent Service.

d.) Is the pump beam hitting approximately the center of the P1 and P4 pump optics and the Ti:Sapphire crystal? If not, refer to the Mira-900F Operator's Manual.

e.) Is the slit clipping the fluorescence beam? If yes, adjust the slit horizontally.

f.) Is BRF clipping the fluorescence beam? If so, walk the beam; see the Mira-900F Operator's Manual.

g.) Is the beam traveling through BP1 and BP2? If not, refer to the Mira-900F Operator's Manual.

h.) Are fluorescence beams overlapping behind M1? If not, adjust M7; refer to the Mira-900F Operator's Manual.

6. Perform the auxiliary CW cavity alignment procedure [5-19].

a.) Remove the slit.

b.) Toggle to CW mode on the controller.

c.) Turn the BP1 micrometer clockwise to the end of its travel.

d.) Center the green reflected beam on M8 and M9 (use alignment fixture).

e.) Overlap the green beams coming from M8 and from M9 (use M9 and alignment fixture).

f.) Set M4 so the fluorescence beam goes through the starter left arm and hits the center of M3.

g.) Adjust M3 to center the fluorescence beam on the gold aperture before M2 (center aperture first).

h.) Verify that the fluorescence cleanly passes through the BRF.

i.) Center the fluorescence from M2 onto the output coupler M1.

j.) Adjust M1 to retro-reflect the back reflection from M1 to M2.

k.) Place a white card behind M1.

l.) Adjust M9 to overlap the two fluorescence beams on the card.

m.) Fine-tune M1 and M9 until lasing occurs.

n.) Optimize the power with P2, M1 and M9.

o.) Tune to ~ 800 nm.

p.) Turn counterclockwise BP1 until output power drop by about 50%.

q.) Center M6 aperture on diffracted red beam.

r.) Translate BP2 until the red beam is diffracted to M7.

s.) Adjust horizontal of M6 to position the beam to the right of the center of M7.

t.) Adjust vertical. of M6 to center on alignment fixture before M7.

u.) Adjust vertical and horizontal of M7 to overlap back-reflection from M7 through the gold aperture on M6.

v.) Fine tune M7 until a small power jump appears on the power meter.

w.) Turn BP1 clockwise about 4 turns.

x.) Optimize M1, M7, P2 for best CW power.

y.) Replace the slit and center it.

z.) Open the slit completely.

CW Power Optimization (CW Lasing Achieved)

7. Verify CW output power.
   a.) Toggle to CW mode on the control box.
   b.) Place a power meter in front of the Mira output.
8. Optimize CW output power [4-7].
   a.) Adjust the pump control P2.
   b.) Adjust the cavity end mirror M7 (and M1 if necessary).
9. Open covers, clean dirty optics, and re-optimize [4-9].
   a.) See Mira step 4 on page 4-23 of this manual.
10. Perform system checks [4-7].
   a.) Are the water cooling temperature and pressure OK? If not, refer to the chiller manual.
   b.) Is the displayed Verdi pump power at its actual output power? If not, refer to Verdi flowchart beginning on page 4-29 of this manual.

c.) Is the pump beam hitting approximately the center of the Ti:Sapphire crystal? If not, refer to the Mira-900F Operator's Manual.

d.) Is the slit clipping the beam? If yes, adjust slit horizontal.

e.) Is the BRF clipping the beam? If yes, refer to the Mira-900F Operator's Manual.

f.) Is the beam traveling completely through BP1 and BP2? If not, refer to refer to the Mira-900F Operator's Manual.

g.) Is the beam roughly centered on all optics except M6 and M7? If not, walk the beam; refer to the Mira-900F Operator's Manual.

11. Perform the auxiliary CW cavity alignment procedure [5-19]

    a.) See Mira step 6 on page 4-23 of this manual.

Modelocking the System (CW Lasing Optimized)

12. Seek for modelocking [5-16].

    a.) Set controller to ML mode.

    b.) Connect Mira "Photocell Ref. Out" to oscilloscope.

    c.) Oscilloscope settings:

    - 10 mV/div
    - 20 ns sweep
    - Trigger of fast diode input

13. Optimize the slit [4-6].

    a.) Center the slit.

    b.) Adjust the slit width until Modelock power is optimized and CW power vanishes.

14. Perform system checks [4-8]. (Standard settings and other information are in parentheses after each check below.)

    a.) Is there lasing in main cavity? (M8 and M9 out of cavity)

    b.) Ensure that BP2 intercept beam is at the tip (approximately 2 mm in at 780 nm).

    c.) Is a Nitrogen purge needed? (> 890 nm)

    d.) Is the BRF is at its efficiency peak setting?

    e.) Is the starter operational? (control box set to ML)

    f.) Is the CW output pump power OK?

g.) Is the pump transverse mode profile at TEM_{00}? If not, contact Coherent Service.

h.) Does the oscilloscope trace look as indicated in the Mira-900F Operator's Manual?

i.) Set oscilloscope sweep to 0.1 ms. Is there any pulse envelope modulation? If yes, open the slit slowly.

15. Re-optimize the system [4-7].

a.) Set ML mode on controller.

b.) Center slit.

c.) Adjust slit width until Modelock power is optimized and CW power vanishes.

d.) Set BRF to maximum efficiency wavelength micrometer position.

e.) Peak pump controls P2.

f.) Peak cavity end mirror (M7, and M1).

g.) Tune BP2. If no modelocking can be achieved, then re-optimize the cavity.

System Optimization (Modelocked Lasing Achieved)

16. Optimize Mira output [4-7].

a.) Oscilloscope trace (10 mV, 20 ns sweep): seek for Figure 4-2 or 4-3 traces as shown in the Mira-900F Operator's Manual.

b.) Adjust slit width to achieve Figure 4-3 trace.

c.) Set sweep to 0.1 ms. Is there any pulse envelope modulation? If so, then open slit width.

d.) Adjust BP2 and slit until you achieve a stable pulse trace.

17. Optimize Mira pulse width [4-8].

a.) Set autocorrelator in front of Mira output (tap off beam).

b.) Tune BP2 to minimize pulse width.

c.) Monitor output power for best trade-off (power vs. pulse width).

d.) Verify beam profile.

e.) Re-peak M7, M1, and P2.

Verdi Platform

Materials Required

- Laser safety glasses (at 532 nm)
- Power meter (0 to 15 W)
- Multimeter

Optical Layout

General optical layout for the Verdi platform is shown in Table 4-11.

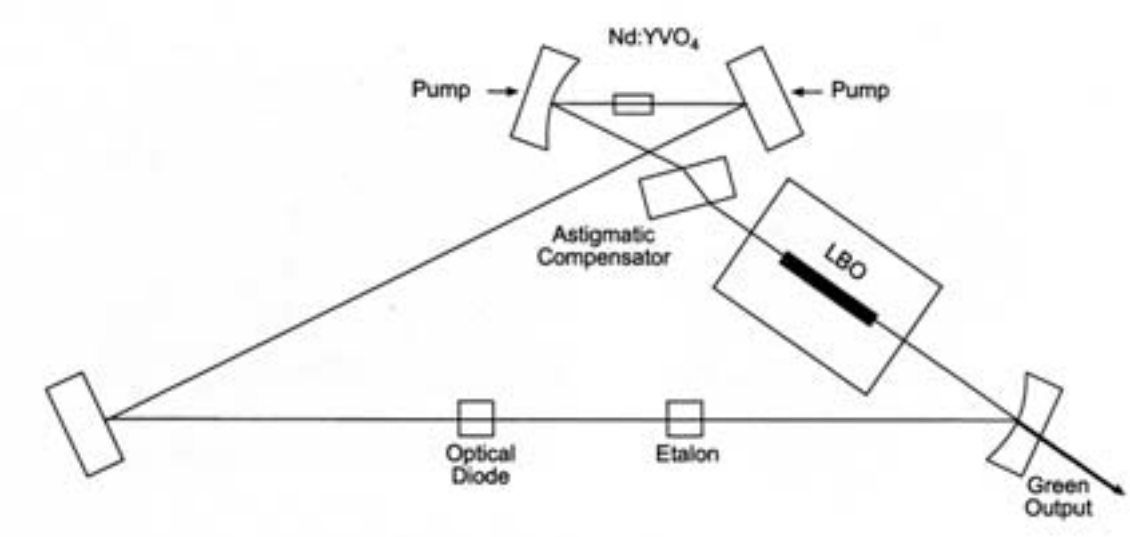


Figure 4-11. Optical Layout, Verdi Platform

Verdi Platform Flow Boxes Details

System Initialization

1. Perform preliminary turn on procedures [4-3].
   a.) Note all laser safety procedures (wear goggles, etc. See Chapter One: Laser Safety).
   b.) Turn cooling water on.
   c.) Verify that the external interlock is in place.
   d.) Set key to “standby” mode.
   e.) Turn the controller box back power switch on.
   f.) Warm up LBO and Vanadate crystal.
   g.) With the shutter closed, turn the control key on.

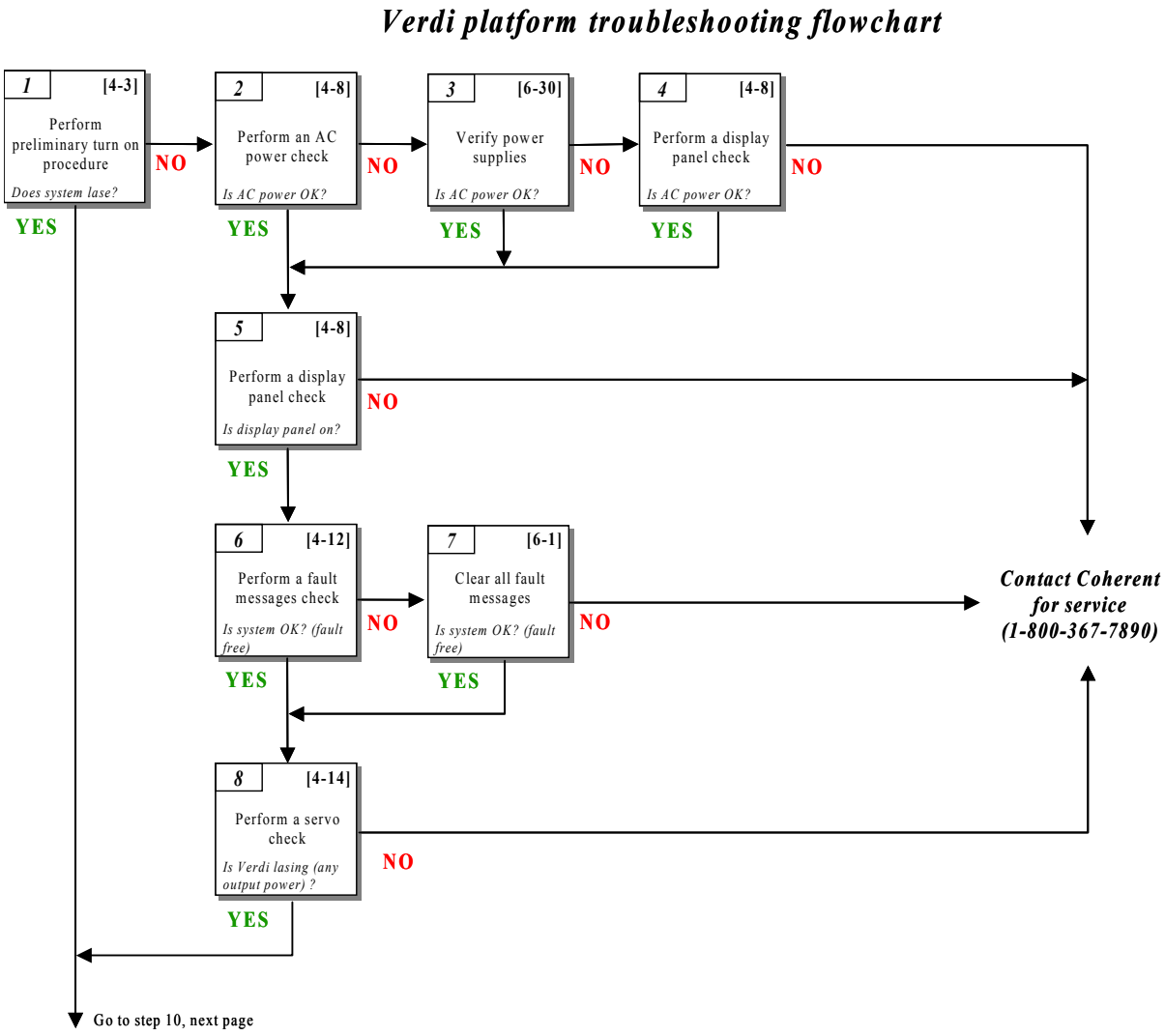


Figure 4-12. Verdi Flowchart 1

h.) When all servos are locked (except laser), open the shutter.

2. Perform an AC power check [4-8].

   a.) Check the front panel LED AC indicator.

3. Verify power supply [6-30].

   a.) Verify facility power.

   b.) Verify power supply fuse (back of controller).

4. Perform a display panel check [4-8].

   a.) Is display panel working?

   b.) Are other indicators on the power supply front panel lit?

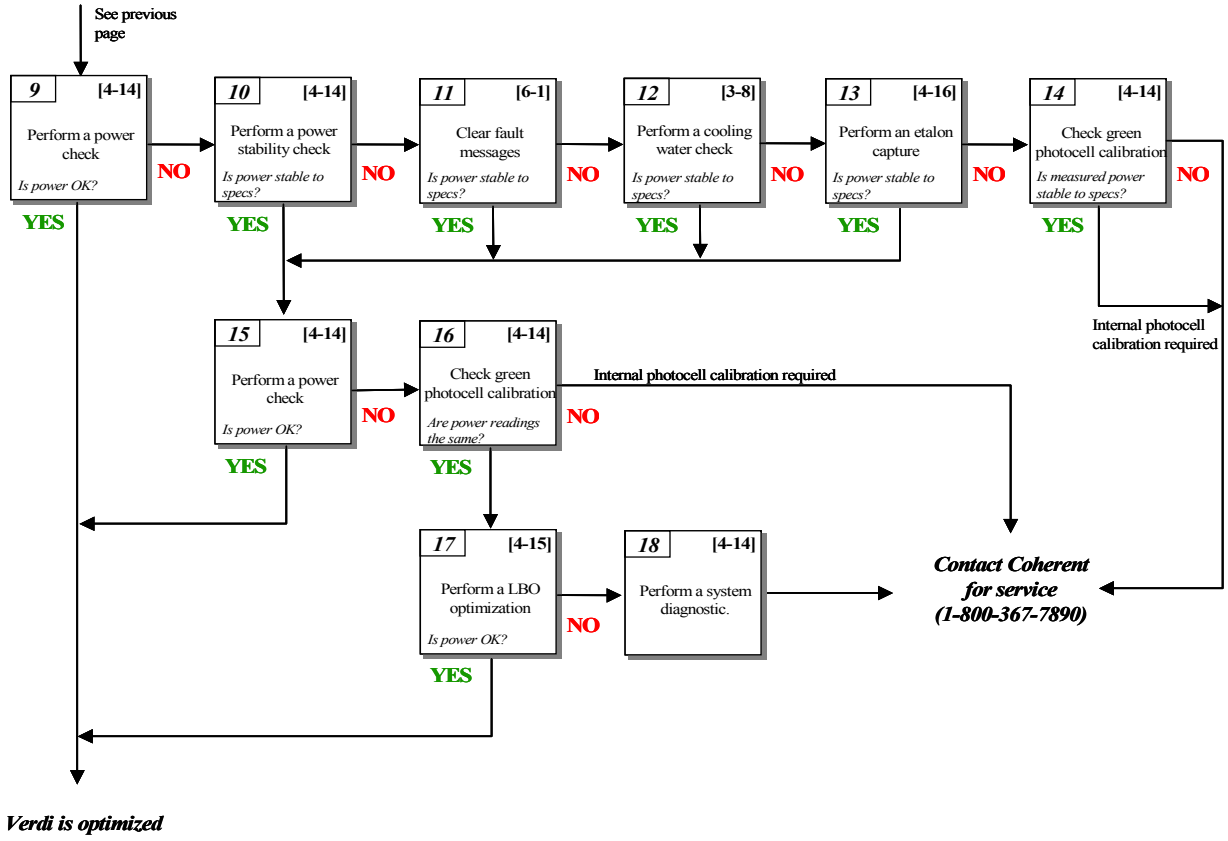


Figure 4-13. Verdi Flowchart 2

5. Perform a display panel check [4-8].
   a.) See front panel display.
6. Perform a fault messages check [4-12].
   a.) Scroll down to "FAULT Status" submenu, and press SELECT.
7. Clear all fault messages [6-1].
   a.) Follow fault troubleshooting charts (see Table 6-1 in the operator manual).
8. Perform a Servo check [4-14].
   a.) Ensure controller key is turned on and the shutter is opened.
   b.) Select "SERVO Status" submenu.
   c.) Ensure proper Verdi warming time.
   d.) Ensure that all servos are locked.

e.) Are servo parameters matching last calibration parameters?

Power Optimization

9. Perform a power check [4-14].
   a.) Press EXIT twice to enter top menu.
   b.) Adjust power to desired level.
   c.) Monitor power from “Servo status” submenu.
10. Power stability check [4-14].
   a.) Under the Servo status submenu, look at either:
      - External power meter
      - Green photocell
   b.) Wait until power reaches the set point.
   c.) Monitor power over 1-2 min.
11. Clear fault messages [6-1].
   a.) Follow fault troubleshooting charts (see Table 6-1 in the Verdi Operator’s manual).
12. Perform a cooling water check [3-8].
   a.) Check the cooling water flow rate.
   b.) Check the cooling water temperature.
   c.) Check the tubing connections.
13. Perform an “etalon capture” [4-16].
   a.) From base menu, select “Etalon capture” submenu.
   b.) Press SELECT to capture.
14. Check green photocell calibration [4-14].
   a.) Set an external power meter at the output.
   b.) Monitor external power for approximately 1 to 2 min.
15. Perform a power check [4-14].
   a.) Set the power to the desired level.
   b.) Adjust the power to the desired level.
   c.) Monitor power from “Servo status” submenu.
16. Check green photocell calibration [4-14].
   a.) Select “Servo status” submenu.

b.) Set an external power meter at the output.

c.) Compare the two power readings.

17. Perform an LBO optimization [4-15].

    a.) Check that all servos are locked.

    b.) Record initial LBO temperature.

    c.) Select LBO optimization submenu.

    d.) Wait until optimization is completed (up to 5 hours).

18. Perform a system diagnostic [4-14].

    a.) Select “Laser status” submenu.

    b.) If Head hours >> or << Diode hours: FAPs were changed in the field.

    c.) If “Over current fault” occurs before reaching set power: FAP current calibration is required.

    d.) If head hours is high, diode currents are high (go to diode parameters submenu) and IR photocell voltage < 2.5 V: FAP is failing.

    e.) If hours are OK, IR Photocell voltage is OK, and FAP current is low: reboot the controller.

Periodic Maintenance Procedures

Daily

- Optimize laser system performances (use flowcharts)
- Verify chiller water temperature, and that the chiller temperature is constant (± 0.01°C); if unstable for more than 5 minutes after turn-on, contact Coherent
- Ensure laser safety in the laser room
- Check beam profile quality (quick check using a card)
- Keep track (log book) of laser performances (see template on next page)

Weekly

- Keep track of any troubleshooting actions taken with the laser (alignments, move, problems, etc.)
- Verify chiller water level
- Verify that the optics are clean

Monthly or Longer

- Every 4-6 months, backwash the water tank and refill with new deionized water
- Every month, verify the N_2 level. Re-fill if necessary.
- Every month, verify that the Verdi control box air filter is clean; clean if required.

Yearly or Longer

- Every year, clean the air filter in the chiller unit.
- Every year, clean the air-dust filter in the Verdi controller box (bottom of front panel).
- Every year, verify the calibration of the OPA. Contact Coherent for a service call if necessary.
- Every 2-3 years, verify the calibration of the power meters.

Daily Data Log Template

Photocopy and use this template to maintain a daily log of the laser function.

Table 4-1. Daily Logs

Date: _____ Lab Temperature: _____ Lab Humidity: _____

Verdi (Mira Pump)		Mira	
Verdi output power	_____ W	Mira output power @ 800 nm	_____ mW
FAP-1 current	_____ A	Pulse width (AC trace)	_____ fsec
FAP-2 current	_____ A	RegA	
FAP-1 hours	_____ H	RegA output power @ _____nm	_____ mW
FAP-2 hours	_____ H	Pulse width (AC trace)	_____ fsec
Verdi (RegA Pump)		OPA	
Verdi output power	_____ W	OPA output power @ _____ nm	_____ mW
FAP-1 current	_____ A	OPA output power @ _____ nm	_____ mW
FAP-2 current	_____ A	OPA output power @ _____ nm	_____ mW
FAP-1 hours	_____ H	Delay 1mic @ _____ nm	_____ mm
FAP-2 hours	_____ H	Delay 2mic @ _____ nm	_____ mm

Date: _____ Lab Temperature: _____ Lab Humidity: _____

Verdi (Mira Pump)		Mira	
Verdi output power	_____ W	Mira output power @ 800 nm	_____ mW
FAP-1 current	_____ A	Pulse width (AC trace)	_____ fsec
FAP-2 current	_____ A	RegA	
FAP-1 hours	_____ H	RegA output power @ _____nm	_____ mW
FAP-2 hours	_____ H	Pulse width (AC trace)	_____ fsec
Verdi (RegA Pump)		OPA	
Verdi output power	_____ W	OPA output power @ _____ nm	_____ mW
FAP-1 current	_____ A	OPA output power @ _____ nm	_____ mW
FAP-2 current	_____ A	OPA output power @ _____ nm	_____ mW
FAP-1 hours	_____ H	Delay 1mic @ _____ nm	_____ mm
FAP-2 hours	_____ H	Delay 2mic @ _____ nm	_____ mm

PARTS LIST

Parts can be ordered by contacting Coherent Customer Service at 1-800-0367-7890 (within USA) or 1-408-764-4557 (outside USA), or your local Coherent representative. Consult the Operator's Manual for your specific system for details.

WARRANTY

Consult the Operator's Manual for your specific system for any deatils regarding the Warranty.

GLOSSARY

µj	Microjoules = 10^{-6} Joules
µm	Micrometer = 10^{-6} meters
µs	Microseconds = 10^{-6} seconds
BBO	Beta-Barium Borate
CDRH	Center for Devices and Radiological Health (U.S. Government)
CFR	Code of Federal Regulation
CW	Continuous wave
dB	Decibels
ESD	Electrostatic discharge
fs	Femtoseconds = 10^{-15} seconds
FWHM	Full width half maximum
GVD	Group velocity dispersion
Hz	Hertz or cycles per second (frequency)
IR	Infrared
kg	Kilograms = 10^{3} grams
kHz	Kilohertz = 10^{3} hertz
LBO	Lithium Triborate
LED	Light emitting diode
MHz	Megahertz = 10^{6} Hz
mg	Milligrams = 10^{-3} grams
mJ	Millijoules = 10^{-3} Joules
mm	Millimeters = 10^{-3} meters
ms	Milliseconds = 10^{-3} seconds
mW	Milliwatts = 10^{-3} Watts (power)
nm	Nanometers = 10^{-9} meters (wavelength)
OPA	Optical parametric amplifier
QS	Q-switch
RegA	Regenerative amplifier
SHG	Second harmonic generation
SPM	Self phase modulation
TEM_{00}	Temporal mode “00”

UV	Ultraviolet
W	Watts
WBSF	Whole beam self-focusing

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Ultrafast Lasers Troubleshooting Guide

Coherent Part Number 1086633, Rev AA