Operation and Maintenance Manual
for the
Precision II Series Lasers

996-0255
rev. b

System Operation Data Sheet
Project #:
Date:
User:

WARNING

*The voltage setting on the PU600C series power units at the time of installation, may **NOT** be exceeded without consulting the Continuum Service office first. Exceeding the designated voltage can result in free-running (see Section II), thermal focusing and optical damage. Failure to follow these precautions will result in voiding the warranty (see Section VII).*

Energy Measured	Spec. Energy	Wavelength	Voltage	CB delays

Oscillator Burns		Amplifier Burns	

Harmonic Burns		Harmonic Burns	

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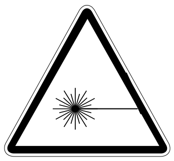
Preface

This manual describes how to operate and maintain the Continuum Precision II series Laser.

Conventions Used in this Manual



LASER RADIATION!

This symbol alerts you to laser radiation hazards during operation or maintenance procedures.

WARNING!

This symbol warns of other possible risks not related to laser radiation or electrical hazards.

CAUTION!

This symbol alerts you to a process or procedure that, if not properly done or followed exactly, will damage the laser or irrevocably change operating software.

This symbol draws your attention to important or extra information that relates to the current subject matter.

Manual Organization

Chapter 1, Safety, provides all the appropriate safety procedures and warning labels. These instructions must be followed to ensure safe operation of the laser equipment.

Chapter 2 describes operating instructions for the Precision II series lasers. A brief installation description is given at the end of the chapter. Installation of this laser may only be performed by a Continuum customer engineer.

Chapter 3 describes the electronic modules and how they work in detail. These descriptions are enhanced with schematics and drawings.

Chapter 4 describes the routine maintenance procedures to keep the equipment operating properly. Only those procedures listed may be performed by the operator.

Chapter 5 describes troubleshooting procedures to use should the equipment malfunction.

The manual includes parts lists of commonly used components. The Appendix gives our warranty and phone numbers. An Index is provided at the end of the manual.

Related Documents

Continuum Documents:

Operator's Manual for the Continuum NY80 Series Pump Laser, COM 996-0155.

Operator's Manual for the Continuum NY60 Series Pump Laser, COM 996-0156.

Operator's Manual for the Continuum Surelite Series, COM 996-0176 & 996-0177.

Laser Safety:

American National Standard for the Safe Use of Lasers, 1986.

Laser Safety Guide, Laser Institute of America, 1977.

Sylvania Safety Rules, Frank S. Canario, Safety Engineer, 1967.

A guide for Control of Laser Hazards, American Conference of Governmental Industrial Hygienists, 1976.

Chapter I Laser Safety Precautions Contents

Chapter I Laser Safety Precautions

Government and industry regulations

Continuum's user information is in compliance with section 1040.10 of 21 CFR Chapter I, Subchapter J concerning Radiological Health published by U.S. Department of Health & Human Services Center for Devices & Radiological Health, 1988 and EN 60825-1, safety of lasers.

The American National Standards Institute (ANSI), a member of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), has published a booklet on laser safety standards. Continuum strongly suggests that all its customers purchase a copy of the American National Standard for the Safe Use of Lasers in order to read and implement necessary precautions. Write or call the publisher listed below for information on obtaining a copy of ANSI Z136.1-1993.

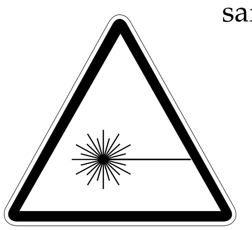
Publisher:	Laser Institute of America 13501 Ingenuity Drive Suite 128 Orlando, FL 32826	
	Telephone	+1(800) 345-2737
	FAX:	+1(407) 380-5588
	e-mail:	lia@laserinstitute.org
	Web(Internet):	http:/www.laserinstitute.org

CAUTION

Only operators experienced in working with lasers and trained by a Continuum service engineer should use and service the Powerlite Precision 9000 Laser, or the warranty will be voided.

Laser safety precautions

The following is a summary of general safety precautions which are to be observed by anyone working with the laser. For a complete listing of safety standards see the ANSI booklet listed above.



1) This laser equipment must be located in a locked area with access only to authorized personnel. The area must be marked by well-defined warning signs, and off limits to unauthorized personnel.

2) This laser equipment may only be operated by qualified personnel, who have also been trained by a Continuum customer service engineer.

3) This laser equipment must be turned off when not in use.

4) Always wear laser goggles appropriate for the wavelength generated and the beam intensity.

5) The laser equipment area must be brightly lit so the pupils of the operator's eyes are normally constricted.

6) A fire-resistant background should be placed behind target areas.

7) Surrounding work areas should be coated with a material that absorbs scattered radiation.

8) Operators should not wear or use any object that may reflect laser light such as a watch, ring, pen, etc.

9) Tracking individuals, vehicular traffic, aircraft, or any airborne object using laser radiation is prohibited.

Optical safety

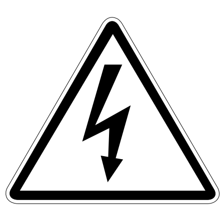
1) Be sure that the light from the flashlamps is obscured from the eye as it is damaging if viewed directly.

2) Eye safety is the greatest concern. Be aware at all times that this is a Class IV laser, the highest and most dangerous classification. Specular reflections from the main beam off a polished surface can cause severe eye damage.

3) Be sure that there are no volatile substances in the lab which the laser could ignite.

4) Mark the lab well with warning signs when the laser is operating and provide interlocks for all doors.

Electrical safety



1) To prevent accidents due to electrical shock, care should be taken to be sure the capacitors are completely discharged and the power turned off before any maintenance or repairs are made to the system. Electric shock and burns resulting from input power or capacitor discharge can cause serious injury or death.

2) Be aware that high voltages are present in the laser heads once ac power is toggled on.

Laser emission classification

The Precision II is a Class IV Laser.

Protection while working with lasers

When the laser beam is active, there are shutters that cut the beam off, or reduce the intensity of the beam at the Precision II output.

1) A shutter at the output of the Precision II series pump laser cuts off the laser beam.

2) The Precision II has a safety cover over the laser beam area. This cover must be in place during normal operation, and should only be removed while the laser is operating for special procedures only.

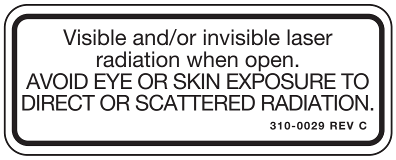
3) The Precision II has a safety interlock that turns off power to all units if the top cover is raised. This cover switch can be defeated using the interlock defeat bracket. This should only be done by a fully trained operator.

Additional safety regulation references

- American National Standard for the Safe Use of Lasers, Laser Institute of America, 1993.
- Laser Safety Guide. Laser Institute of America, (9th Edition).
- Electronic Product Radiation Control, Guidance on Electronic Products which Emit Radiation, Center for Device Radiation and Health (CDRH).
  http://www.fda.gov/cdrh/radhlth/indexhtml
- Guidlines for Laser Safety and Hazard Assessment, PUB 8-1.7, OSHA Directives, 1991

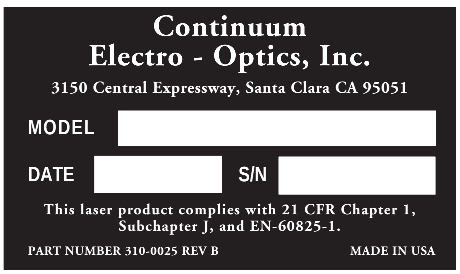
Warnings and labels

Page 1-4 shows some of the warning labels used on the Precision II Laser. Label location diagrams A through D give the location of these labels on the unit.

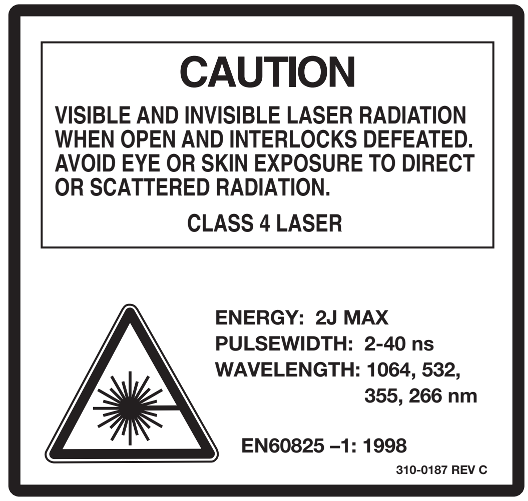


Item 1
P/N 310-0029
Found on top surface of bench, internal covers & on pan under the bench.

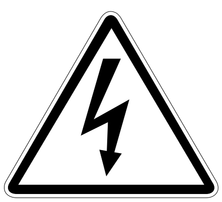
Item 2
P/N 310-0169



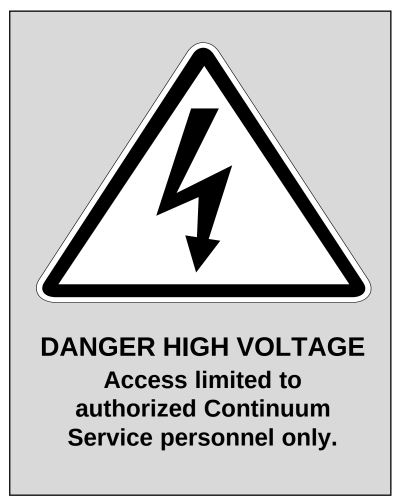
Item 3
P/N 310-0025 REV B



Item 4
P/N 310-0187

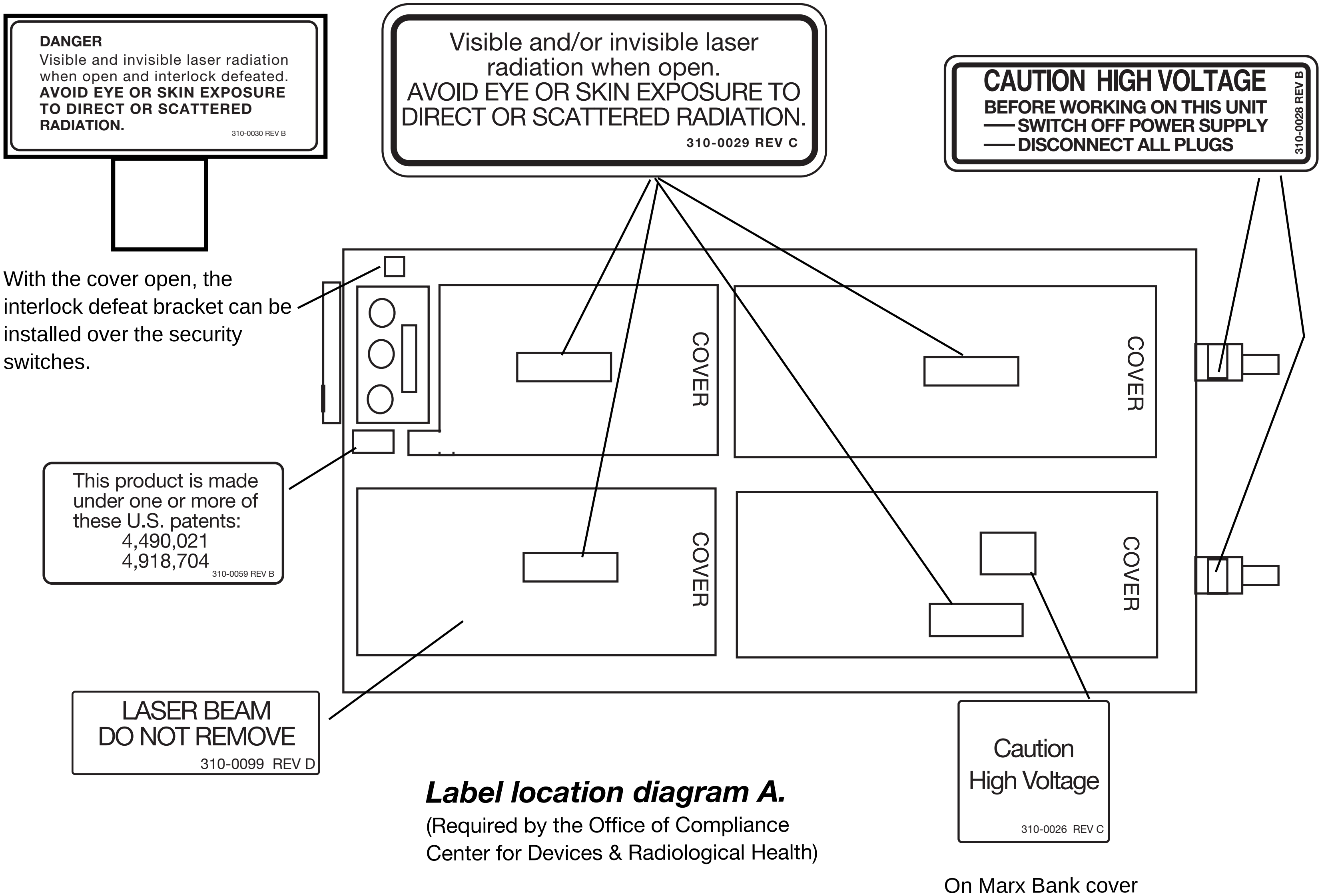


Item 5
P/N 310-0192
Found inside power units on heat sinks, capacitors & 24V power supplies. Also, on rear panels of control units and cooling groups.

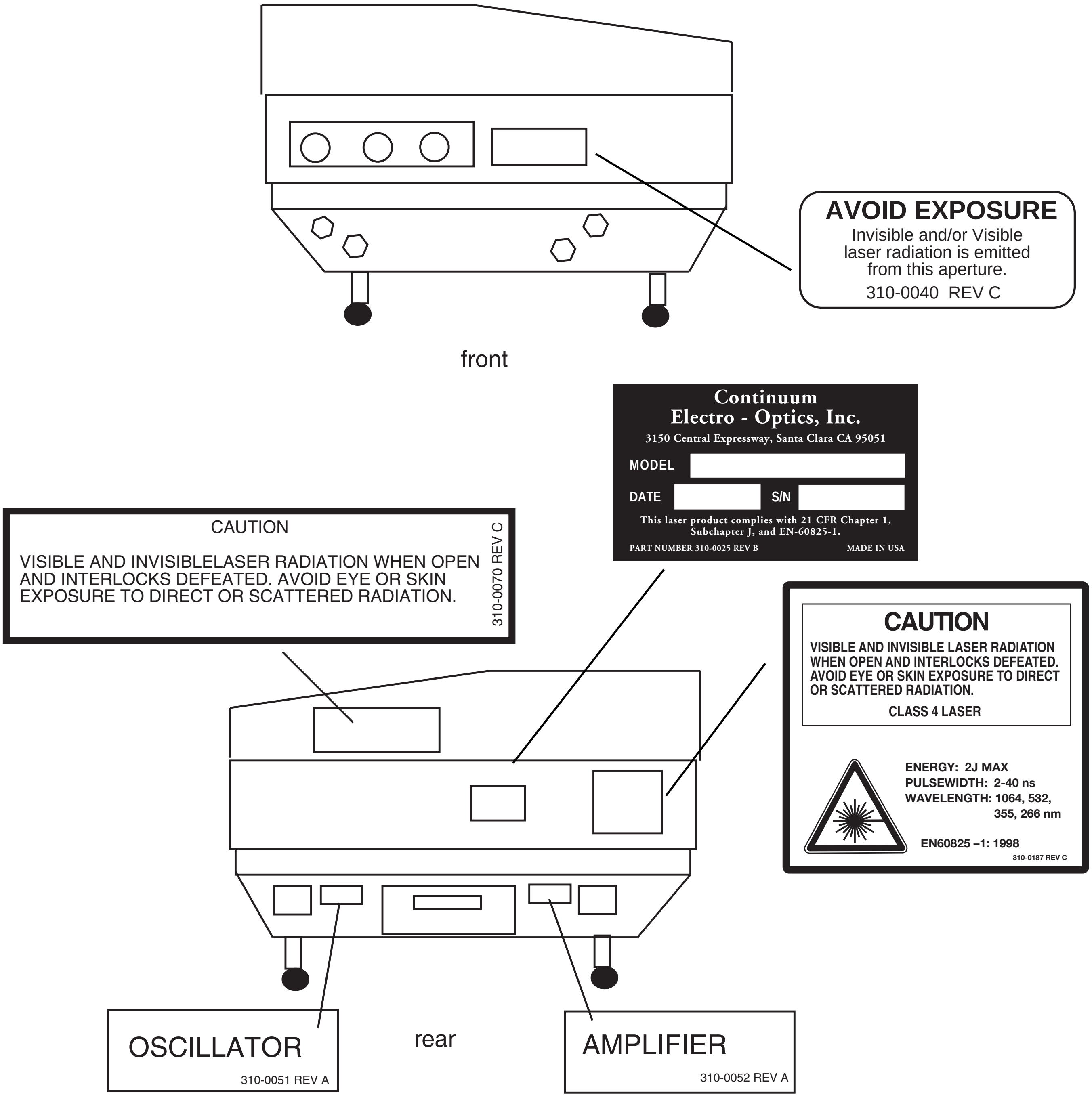


Item 6
P/N 310-0022
Found on the covers of the control and power units, and capacitor banks.

Precision II warning labels.

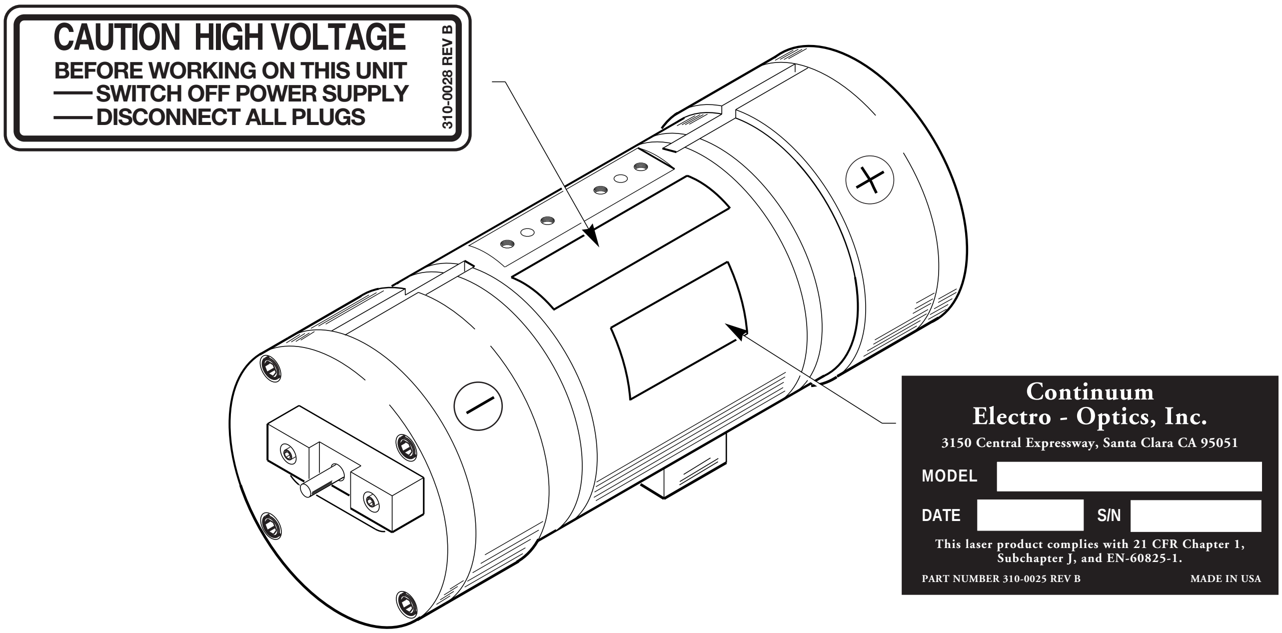


Label location diagram A.
(Required by the Office of Compliance Center for Devices & Radiological Health)



Label location diagram B.

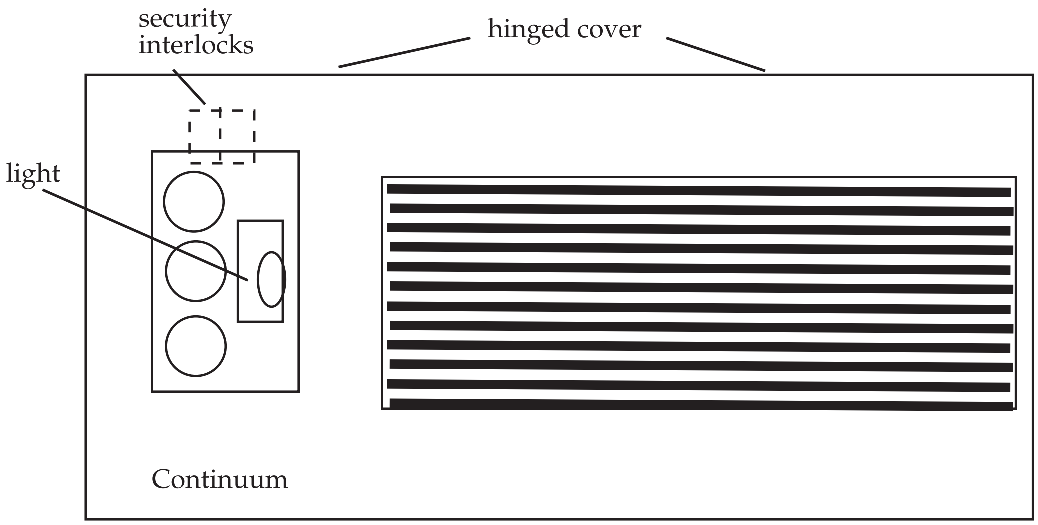
(required by the Office of Compliance Center for Devices & Radiological Health)



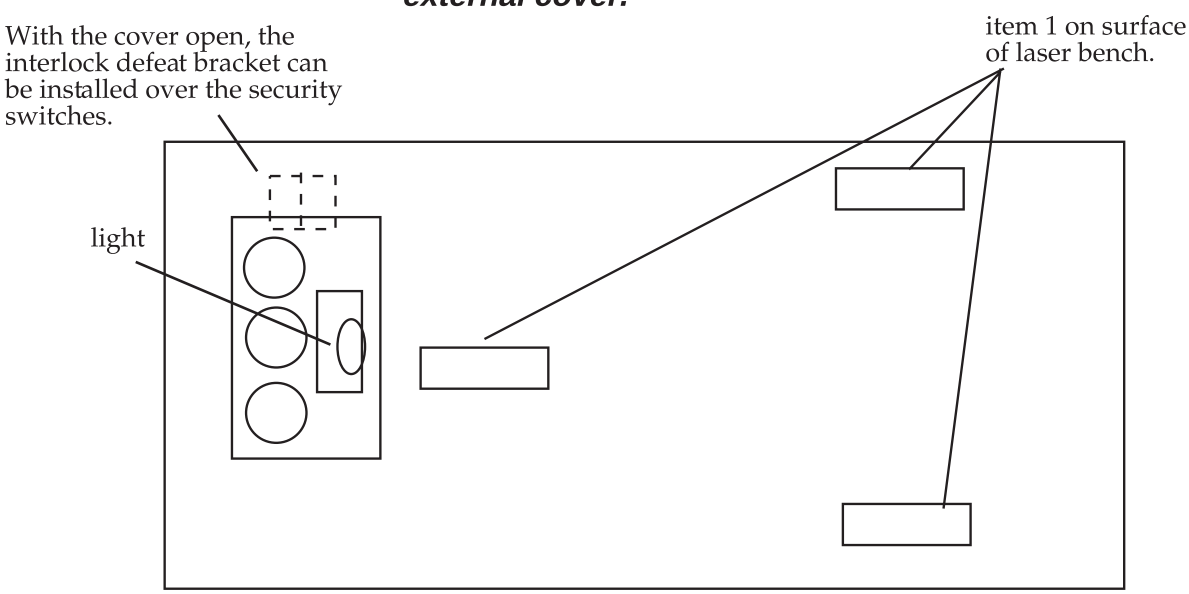
811 head.

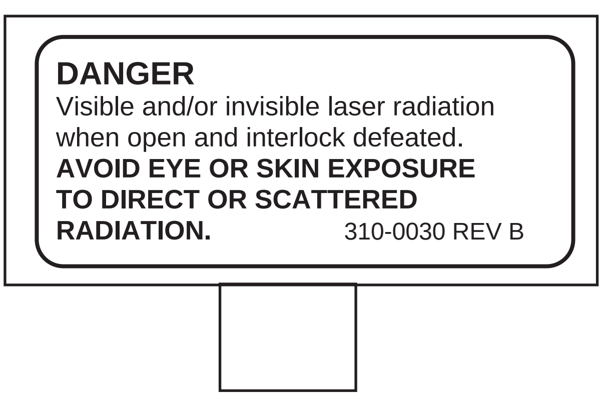
Label location diagram C.

(required by the Office of Compliance Center
for Devices & Radiological Health)



Security interlock location diagram external cover.





Label location diagram D.

(required by the Office of Compliance Center for Devices & Radiological Health)

Interlock Defeat Bracket

KONFORMITÄTSERKLÄRUNG 96

Wir Continuum Scientific
3150 Central Expressway
Santa Clara, CA 95051, U.S.A.

erklären in alleiniger Verantwortung, dab das Produkt:

Precision 9000

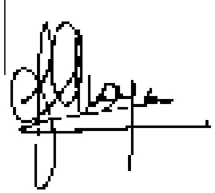
auf das sich diese Erklärung bezieht, mit der/den folgenden Normen oder normativen Dokumenten übereinstimmt:
EN 55011:1991 Radiated
EN 55011:1991 Conducted
ENV50140
ENV50204
EN61000-4-2
ENV50141
EN6100-4-4

Gemäb den Bestimmungen der Richtlinie

72/23/EEC
89/336/EEC
Santa Clara, CA USA

Date

(François Moya)



DECLARATION OF CONFORMITY 96

We Continuum Scientific
3150 Central Expressway
Santa Clara, CA 95051, U.S.A.

declare under our sole responsibility that the product:

Precision 9000

to which this declaration relates, is in conformity with the following standards or other normative documents:
EN 55011:1991 Radiated
EN 55011:1991 Conducted
ENV50140
ENV50204
EN61000-4-2
ENV50141
EN6100-4-4

Following the provisions of Directives

72/23/EEC
89/336/EEC
Santa Clara, CA USA

Date

(François Moya)

DÉCLARATION DE CONFORMITÉ 96

Nous Continuum Scientific
3150 Central Expressway
Santa Clara, CA 95051, U.S.A.

déclarons sous notre seule responsabilité que le produit:

Precision 9000

auquel se réfère cette déclatation est conforme aux normes ou autres documents normatifs:

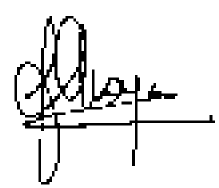
EN 55011:1991 Radiated
EN 55011:1991 Conducted
ENV50140
ENV50204
EN61000-4-2
ENV50141
EN6100-4-4

conformément aux dispositions des Directives

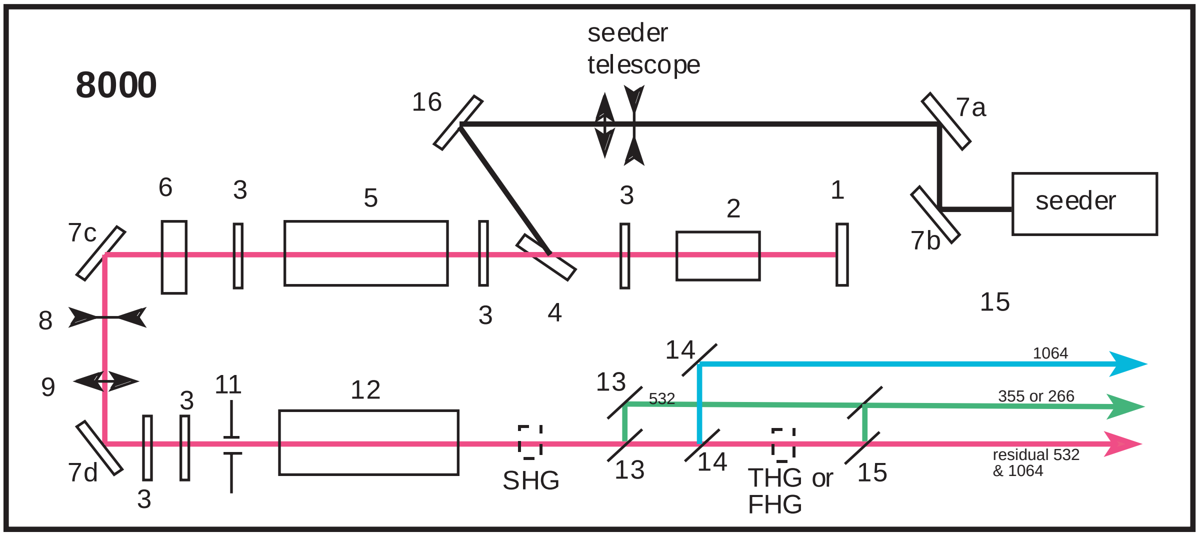
72/23/EEC
89/336/EEC
Santa Clara, CA USA

Date

(François Moya)

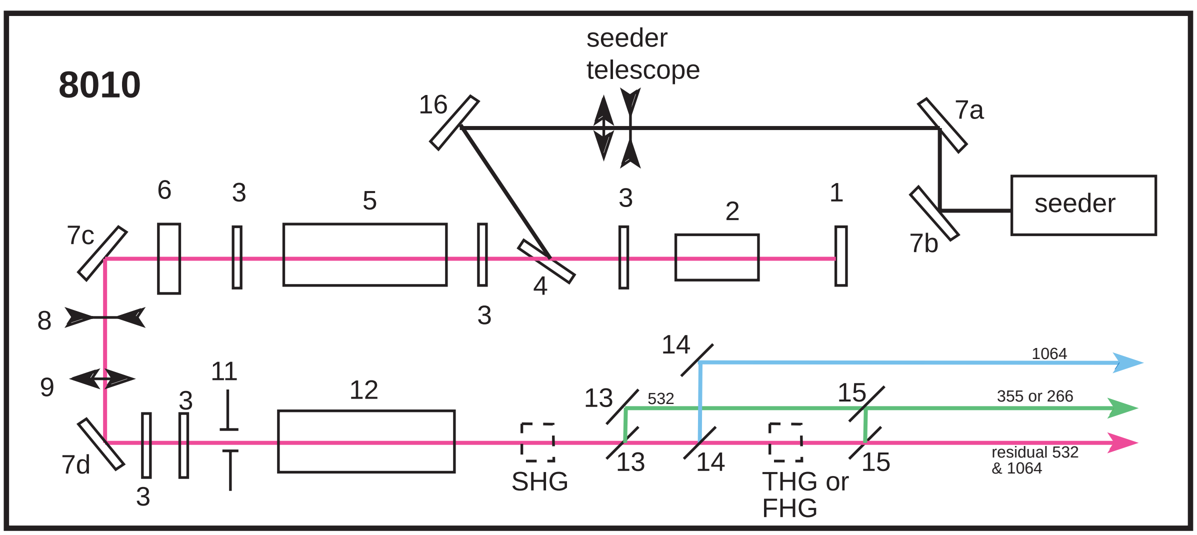


Chapter II System Operation Contents



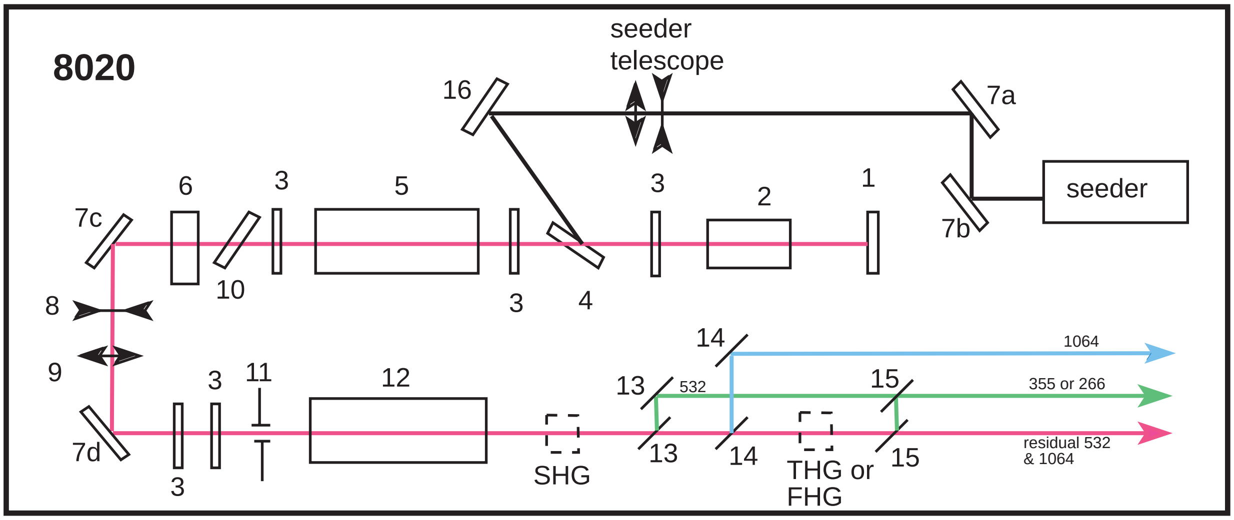
Legend for Precision 8000

1. Mirror, rear, (rep rate dependent)
2. Pockels cell, 202-0003
3. λ/4 plate, 108-0001
4. Dielectric polarizer, 199-0116
5. 811U-06 head, 507-0700
   rod, 6mm, 201-0056
   flashlamp, 203-0019
6. Output coupler, (rep rate dependent)
7. Mirror, turning, 45°, 105-0002
8. Div. lens, -104mm, 102-0005
9. Con. lens, +155mm, 101-0001
10. Not used
11. Pinhole
12. 812V-09 head, 507-0900
    rod, 9mm, 201-0005
    flashlamps, 203-0032
13. Dichroics, 532nm, 105-0022
14. Dichroics, 1064nm, 105-0002
15. Dichroics. 355nm, 105-0023
    or 266nm, 105-0025
16. Mirror, 20-32°, 105-0086



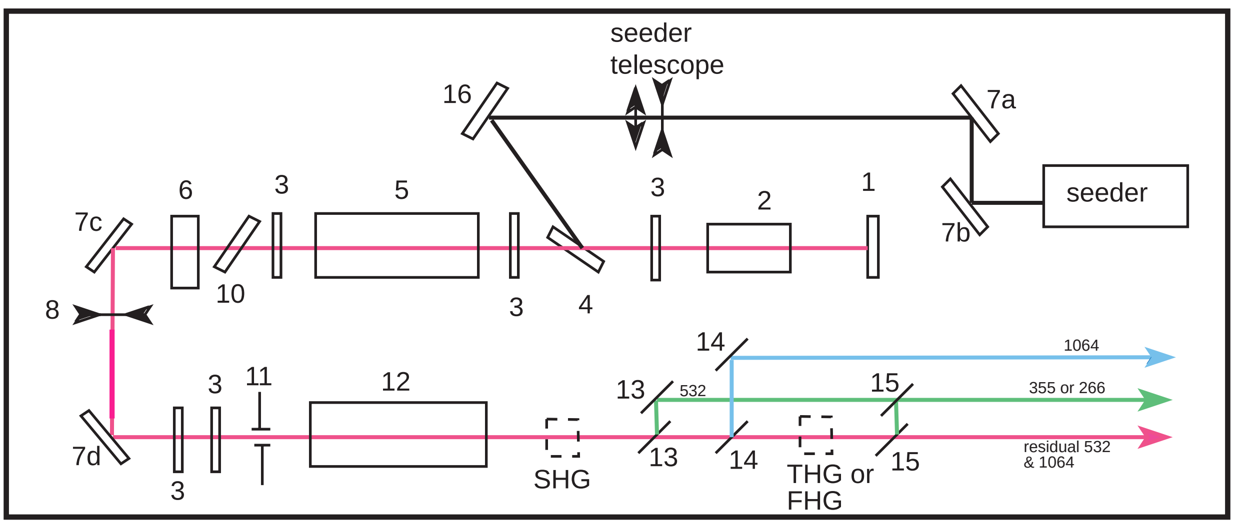
Legend for Precision 8010

1. Mirror, rear, (rep rate dependent)
2. Pockels cell, 202-0003
3. λ/4 plate, 108-0001
4. Dielectric polarizer, 199-0116
5. 811U-07 head, 507-1000
   rod, 7mm, 201-0004
   flashlamp, 203-0035
6. Output coupler, (rep rate dependent)
7. Mirror, turning, 45°, 105-0002
8. Div. lens, -104mm, 102-0005
9. Con. lens, +155mm, 101-0001
10. Not used
11. Pinhole
12. 812V-09 head, 507-0900
    rod, 9mm, 201-0005
    flashlamps, 203-0032
13. Dichroics, 532nm, 105-0022
14. Dichroics, 1064nm, 105-0002
15. Dichroics. 355nm, 105-0023
    or 266nm, 105-0025
16. Mirror, 20-32°, 105-0086



Legend for Precision 8020

1. Mirror, rear, (rep rate dependent)
2. Pockels cell, 202-0003
3. λ/4 plate, 108-0001
4. Dielectric polarizer, 199-0116
5. 811U-06 head, 507-0700
   rod, 6mm, 201-0056
   flashlamp, 203-0019
6. Output coupler, (rep rate dependent)
7. Mirror, turning, 45°, 105-0002
8. Div. lens, -104mm, 102-0005
9. Con. lens, +155mm, 101-0001
10. Dielectric polarizer, 199-0055
11. Pinhole
12. 812V-09 head, 507-0900
    rod, 9mm, 201-0005
    flashlamps, 203-0032
13. Dichroics, 532nm, 105-0022
14. Dichroics, 1064nm, 105-0002
15. Dichroics. 355nm, 105-0023
    or 266nm, 105-0025
16. Mirror, 20-32°, 105-0086



Legend for Precision 8030

1. Mirror, rear, (rep rate dependent)
2. Pockels cell, 202-0003
3. λ/4 plate, 108-0001
4. Dielectric polarizer, 199-0116
5. 811U-06 head, 507-0700
   rod, 6mm, 201-0056
   flashlamp, 203-0019
6. Output coupler, (rep rate dependent)
7. Mirror, turning, 45°, 105-0002
8. Div. lens, -2m, 102-0013
9. not used
10. Dielectric polarizer, 199-0055
11. Pinhole
12. 811U-06 head, 507-0700
    rod, 6 mm, 201-0056
    flashlamp, 203-0019
13. Dichroics, 532nm, 105-0022
14. Dichroics, 1064nm, 105-0002
15. Dichroics. 355nm, 105-0023
    or 266nm, 105-0025
16. Mirror, 20-32°, 105-0086

Chapter II System Operation

The System Operation section contains the steps for running the laser on a daily basis. For more detailed operations such as alignment or changing flashlamps, see the Troubleshooting and Maintenance sections.

A. Startup procedure

1) Open city water and drain source connected to laser system.

2) Switch on electronics rack circuit breaker located on front upper right hand side of cabinet. The CG604C pump will also turn on.

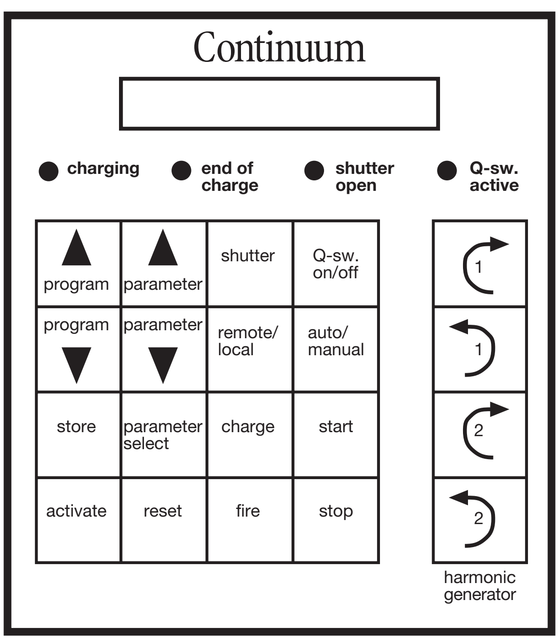
3) Switch **ON** the 24V power supply switch located on rear of electronics cabinet. See drawing on page 3-15.

4) Turn key on front panel of CU601C counter-clockwise to the **ON** position.

5) After approximately 15 seconds the control unit CU601C will complete its system check and countdown. The phrase **MANUAL MODE** is then displayed on the remote box RB601.

```
MANUAL MODE
SHOT COUNT XXXXXXX
```

RB601 keyboard



6) Press the **AUTO/MANUAL** key on the RB601 and then press the **START** key.

7) The system will cycle to programmed mode #1 (PGM1) for system warm-up. The laser heads should now be flashing at the standard rep rate.

8) For lasers with the SI-500 option (Seeded SLM), turn the key switch to the **ON** position (on the seed laser's control panel on the side of the laser head) and the shutter switch to the **CLOSED** position.

9) Allow the system to run for 30 minutes without Q-switching to thermally stabilize the system.

10) Select desired programmed mode of operation by pressing the **PROGRAM UP** key on the RB601.

11) Once the PGM is located press **ACTIVATE** key to engage the desired PGM.

12) For lasers with the SI-500 option (Seeded SLM), flip the shutter switch to the **OPEN** position on the seed laser's control panel .

13) On the RB601 press on the keys **SHUTTER** and **Q-SWITCH**. The four LED's across the top of the RB601 should be on or flashing.

14) Open desired wavelength port and maximize harmonic crystals if necessary.

B. Shutdown procedure

1) Press the **STOP** key on the RB601.

2) Close all wavelength ports.

3) For lasers with the SI-500 option (seeded SLM), turn the key switch to the **STANDBY** position and the shutter switch to the **CLOSED** position on the seed laser's control panel.

4) Turn key on front panel of CU601C clockwise to the **OFF** position.

Caution:

Leaving the seeder in the **ON** position reduces Seed Laser life time and will result in a premature failure of the pumping diode.

5) Leave the 24V power supply switch on rear of electronics rack in the **ON** position.

6) Switch off electronics rack circuit breaker located on front, upper right hand side of cabinet.

7) Close city water and drain source connected to laser system.

C. Programming the RB601 remote box

Through the RB601 you can access a total of 16 Programmed Modes (PGM). The first 3 PGM’s are set at the factory and cannot be changed. The remaining 13 PGM’s can be programmed by the user.

PGM-1 is used for system warm-up. The Q-switch cannot be turned on and the shutter cannot be opened.

PGM-2 is used to take single shot alignment burns at full energy. Q-switch timing and rep rate are optimized.

PGM-3 is used for standard full power operation. System Q-switches with every flash of the laser head.

PGM- 4 to 16 can be programmed by user.

Procedure for programming the PGM's

Note: This is a summation of the programming procedure for PGM’s. Please turn to page 3-26 for a more detailed description.

1) PGM’s 1-3 cannot be changed.

2) A pause during the programming process by >20 seconds will cause the display to revert to the previously activated PGM.

3) The PGM that is **ACTIVE** cannot be reprogrammed. If you wish to change it you must activate another PGM and then come back to the PGM you wish to reprogram.

```
F/x             PGMx
xxHz xxxuS      xxxx
```

4) Select a PGM that is not **ACTIVE** and press the **PARAMETER SELECT** key on the RB601.

5) A cursor will flash under the "Hz" readout on the RB601. Press **PARAMETER UP** or **PARAMETER DOWN** to set desired rep rate. Rep rates cannot be raised above factory optimum. Setting the rep rate below the factory setting increases the potential for rod damage and poor beam quality.

6) Press **PARAMETER SELECT** again and the cursor will move to the Q-switch delay. This can be set from 1 to 999 µs.

7) Press **PARAMETER SELECT** again and the cursor will move to the frequency “F” position. The number you enter is the denominator that divides the flashlamp rep rate to obtain Q-switch rep rate. Example F/5 means that each 5 flashes of the laser head produces one Q-switch pulse.

8) Press the key labeled **STORE** and the program is saved.

9) Press the key labeled **ACTIVATE** and the reprogrammed PGM is implemented.

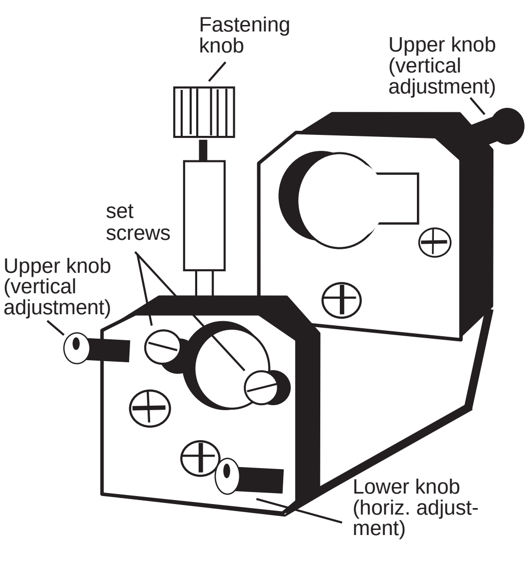
D. Options

The use of the nonlinear crystal KDP allows the generation of Second Harmonic (532 nm) and Third Harmonic (355 nm) from the YAG fundamental (1064 nm). For more information on harmonic generation, see W. Koechner's Solid-State Laser Engineering published by Springer-Verlag, Chapter 10.

Abbreviations used for Continuum's harmonics are as follows:

DS1	Second Harmonic Crystal Type I KD*P
DS	Second Harmonic Crystal Type II KD*P
TS	Third Harmonic Crystal Type II KD*P
QS	Fourth Harmonic Crystal Type I BBO
DS1-S	Second Harmonic Crystal Type I KD*P for seeded system
TS-S	Third Harmonic Crystal Type II KD*P for seeded system
DS-S	Second Harmonic Crystal Type I KD*P for seeded system

Second harmonic generation



Harmonic stage assembly.

For the performance parameters at 532 nm, see the data sheet at the front of manual.

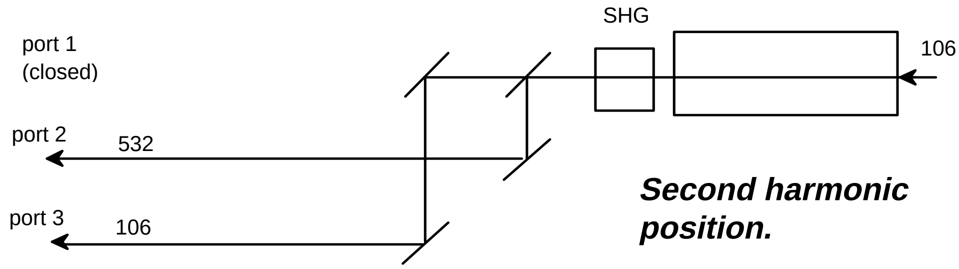
Polarization >95% vertical
Input Polarization 1.06 µ circularly polarized.

Install the Second Harmonic Generator Type II, labeled DS. The crystal DSI can be used, but the harmonic conversion efficiency will be at least 25% less. See procedure below.

1) Perform system Shutdown procedure (see pg. 2-2).

2) Locate the SHG labeled DS and install on SHG mount (see next page for harmonic location).

To install:
a. Identify locking pins and guide pins on harmonic generator and its face plate (see page 2-6).



Second harmonic position.

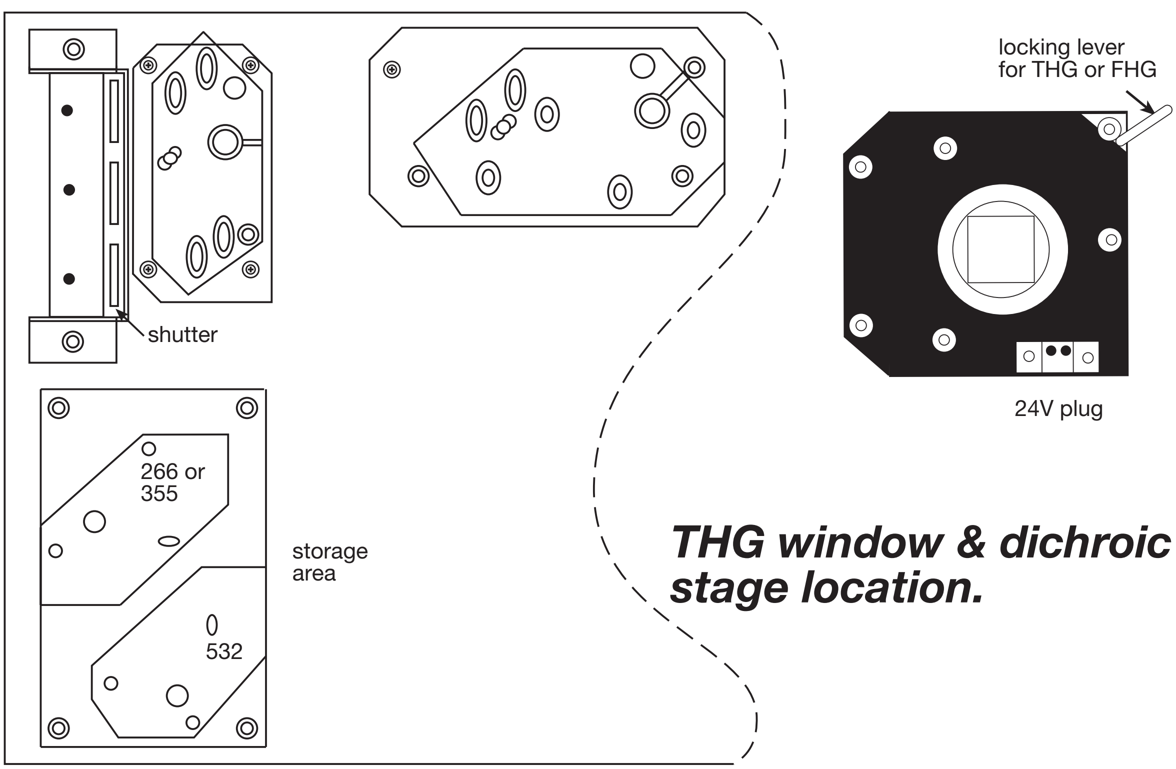
b. Carefully align guide pins to the holes on the face plate and then press the crystal housing firmly against the crystal face plate.

c. Slide the locking lever on the face plate to secure it to the crystal housing.

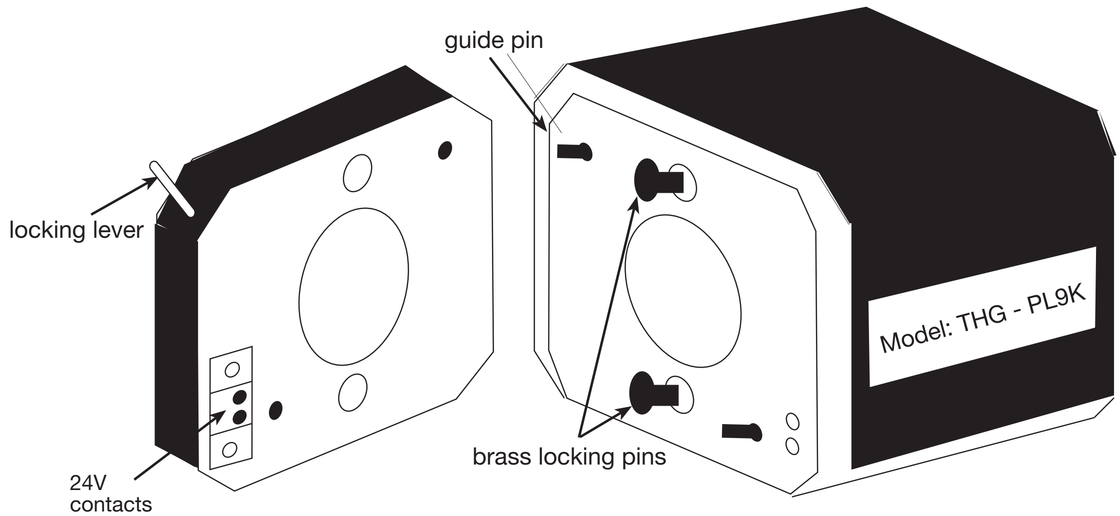
3) Locate the 532 dichroic stage. It should be in the storage area (see below). Install the 532 nm dichroics stage in the 532 location behind the SHG. Securely tighten the tall fastening knob on the dichroic stage (see page 2-4).

Note: If the 1064 nm dichroic is not present on your dichroic stage, the Third Harmonic Generator (THG) must be removed from its mount. Deviation of the 1064 nm as it passes through the 532 dichroics may cause it to clip inside the THG.

4) Turn down the power of the Precision II 9000 so that you can safely check the optical alignment of the 1064 nm



THG window & dichroic stage location.



Connecting harmonic to face plate

through the SHG and out of port #3, and the alignment of the 532 nm through port #2 (see drawing above) .
To reduce power:

a. Locate the delay knob on front of oscillator CB630C and note present reading.

b. Set delay to 550 µs.

c. Perform Daily Startup procedure (see page 2-1).

5) On RB601 adjust crystal position for maximum 532 nm energy.

a. While still at reduced power, place a power meter after port #2 and align 532 nm into center of detector head.

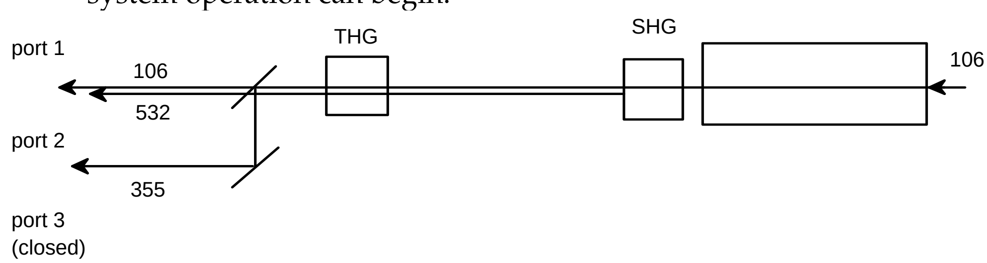
b. Using the RB601, tweak SHG for highest energy.

c. Slowly bring system up to full power by setting the CB630C delay to the value noted in step 4a.

d. Again tweak SHG for highest energy.

6) Harmonic installation is now complete and normal system operation can begin.

Third harmonic position.



Third harmonic generation

For performance parameters at 355 nm , see the data sheet in the front section of the manual:

Polarization	>95% horizontal
Input Polarization	1.06 4 µ horizontally polarized, 532 vertically polarized.

Install the Second Harmonic Generator (SHG) Type I, labeled DSI. See procedure below.

1) Perform system shutdown procedure (see page 2-2).

2) Locate the THG labeled TS and SHG labeled DSI and install on proper mount (see facing page).

To install:

a. Identify locking pins and guide pins on harmonic generator and its face plate (page 2-6).

b. Carefully align guide pins to the holes on the face plate and then press the crystal housing firmly against the crystal face plate.

c. Slide the locking lever on the face plate to secure it to the crystal housing.

3) Remove the 532 dichroic stage located between the SHG and THG. Secure in the storage area.

4) Locate the 355 dichroic stage. It should be in the storage area located adjacent to the FHG (see page 2-5). Install the 355 nm dichroics stage in the 355 location behind the THG (see page 2-6). Securely tighten the tall fastening knob on the dichroic stage (see drawing, page 2-4).

5) Turn down power of Precision II so that you can safely check the optical alignment of the 1064 nm through the SHG and THG and out of port #1. Check the alignment of the 355 nm through port #2.
To reduce power:

a. Locate delay knob on front of oscillator CB630C and note present reading.

b. Set delay to 550 µs.

c. Perform Daily Startup procedure (see page 2-1).

6) On RB601 adjust crystal position for maximum 355 nm energy.

a. While still at reduced power, place a power meter after port #2 and align 355 nm into center of detector head.

b. Using the RB601, adjust the SHG and then the THG for highest energy.

c. Slowly bring system up to full power by setting the CB630C delay to the value noted in step 5a.

d. Again, adjust harmonics for highest energy.

7) Harmonic installation is now complete and normal system operation can begin.

Fourth harmonic generation

For Performance Parameters at 266 nm, see the data sheet in the front of the manual:

Polarization	>95% horizontal
Input Polarization	532 vertically polarized

Install the Second Harmonic Generator (SHG) Type II, labeled DS. The crystal DSI can be used but the harmonic conversion efficiency may be 25% less. See procedure below.

1) Perform system Shutdown procedure (see page 2-2).

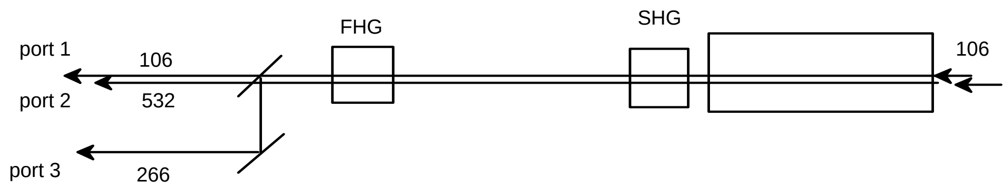
2) Locate the FHG labeled QS-B and SHG labeled DS and install on indicated mount (see facing page).

To install:
a. Identify locking pins and guide pins on harmonic generator and its face plate (see page 2-6).

b. Carefully align guide pins to the holes on the face plate and then press the crystal housing firmly against the crystal face plate.

c. Slide the locking lever on the face plate to secure it to the crystal housing.

3) Locate the 266 dichroic stage. It should be parked in the storage area located adjacent to the FHG (see page 2-5). Install 266 nm dichroics stage in the 266 location behind the FHG. Securely tighten the tall fastening knob on the dichroic stage found on page 2-4.



Fourth harmonic position.

4) Turn down power of Precision II so that you can safely check the optical alignment of the 1064 nm through the SHG and the 532 nm through the FHG. Also check the alignment of the 266 nm through port #3.
To reduce power:

a. Locate delay knob on front of oscillator CB630C and note present reading.

b. Set delay to 550 µs.

c. Perform Daily Startup procedure (page 2-1).

5) On RB601 adjust crystal position for maximum 266 nm energy.

a. While still at reduced power, place a power meter after port #3 and align 266 nm into center of detector head.

b. Using the RB601, adjust harmonics #1, then #2 and then #1 again for highest energy.

c. Slowly bring system up to full power by setting the CB630C delay to the value noted in step 5a.

d. Again adjust harmonics for highest energy.

6) Harmonic installation is now complete and normal system operation can begin.

LNE alignment

Equipment needed:

- LNE option
- IR card
- photodiode (risetime ~1 ns)

Initial alignment

1) Block rear mirror of the oscillator and then adjust the LNE (Line Narrowing Etalon) normal to the optical axis so that the system will lase on the LNE itself. Monitor lasing by using either an IR card, a photodiode or by observing the 532 nm after the Second Harmonic Crystal.

2) Adjust the LNE in the vertical axis until the system stops lasing off the LNE.

3) Turn off the Q-switch at the remote box but leave cavity shutter open.

4) Unblock rear mirror and then check free running threshold by increasing the pump voltage on the flashlamps by 80 volts. There should be no lasing. If lasing is observed, refer to index of Troubleshooting section of this manual for the procedure for eliminating free-running.

5) Return the lamp voltage to the normal setting.

6) Proceed with normal operation.

Fine adjustment

1) Perform the initial alignment of the LNE.

2) Using a 10mm etalon, generate Fabry-Perot fringe pattern in using the 532 nm output of the laser.

3) Using the vertical control of the LNE, make fine adjustments in the position of the etalon to make the Fabry-Perot rings as distinct as possible.

4) Verify that there has been no change in the free-running threshold. If the free-running buffer is reduced, refer to index of Troubleshooting section of this manual for the procedure for eliminating free-running.

5) Check to make sure that the Fabry-Perot rings are still distinct, if not, repeat steps 3 and 4.

6) Proceed with normal operation.

E. External triggering of Precision II series

There are three methods of externally controlling the firing of the Precision II series lasers: Direct Access Triggering (DAT), Stanford Research Pulse Generator and using the laser's RS232 interface.

When using the DAT method, the user sends TTL signals directly to the Precision II, bypassing the internal timing circuitry in its Control Unit computer. Although this method requires a user-supplied TTL trigger circuit, it reduces output jitter to ~1 ns.

With the Stanford Research Pulse Generator box, directions are given with proper settings, page 2-13.

The third method uses your microcomputer to control the laser directly via its RS232 interface. The asynchronous nature of microprocessor computer programs and the RS232 interface makes it difficult to fire the laser at a precisely known time. Details of this method, including an example of control software, begin on page 2-15.

1) Direct Access Triggering (DAT)

DAT may be used to control all Precision series lasers, and is the preferred method of external triggering when accurate output timing (~1 ns jitter) is critical. DAT places both the flashlamp firing and the Q-switch opening under external control. You must supply synchronized fire flashlamps and open Q-switch signals. DAT does not affect the Precision II's safety interlocks (flow, temperature, shutter, etc.).

Equipment needed:

- TTL pulse generator, producing 5 Vdc, 10 µs positive-going pulses
- two BNC cables.

Before setting up Direct Access Triggering, please review the timing chronograph on page 2-12 and schematic 617-9900 on page 3-12. To perform DAT:

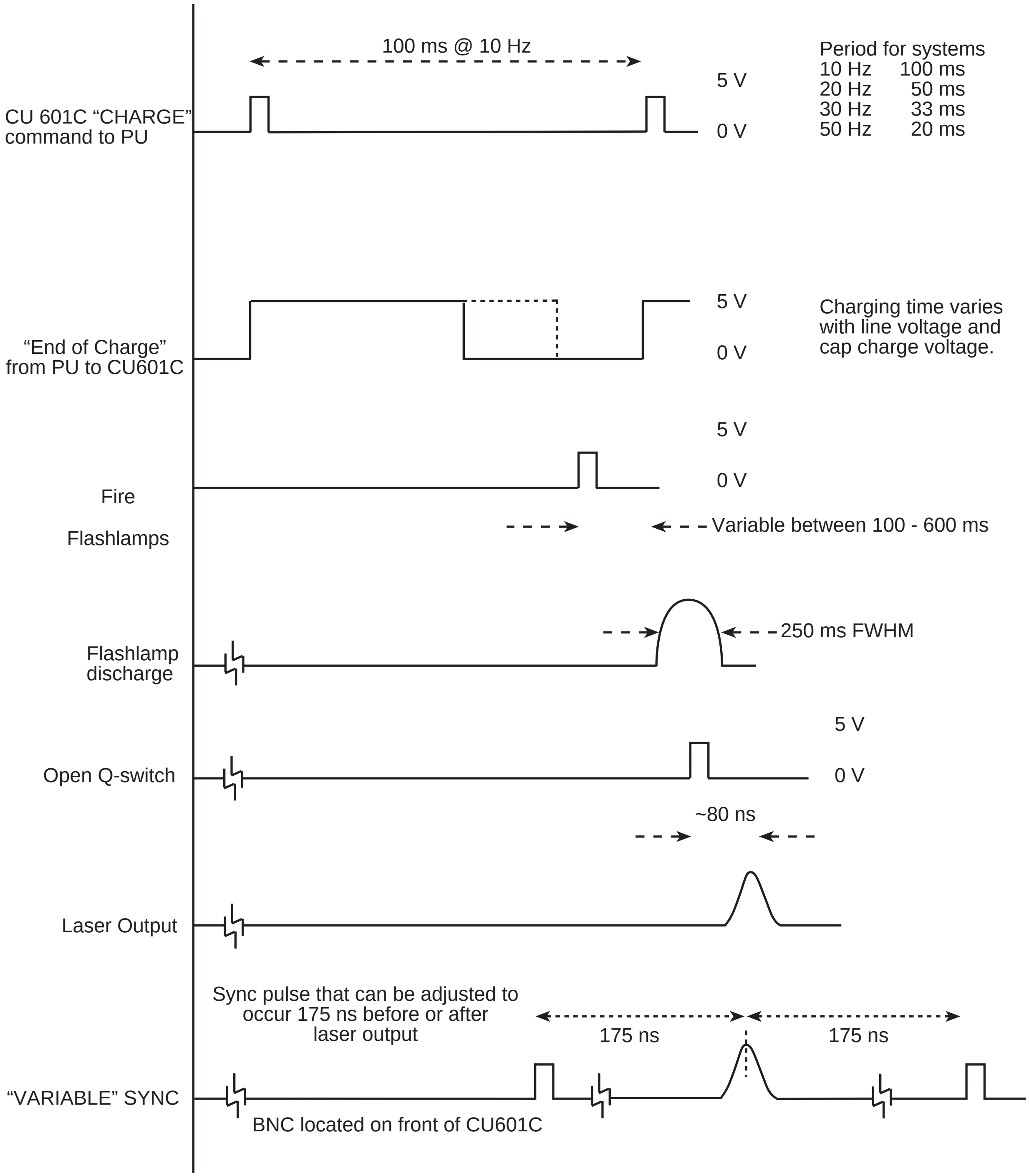
1) Connect a cable between your external pulse generator and the EXT flashlamp trig in BNC on the Precision's External Trigger Panel (ETP). The ETP is shown on page 2-14. This cable will carry your externally supplied fire flashlamps signal.

2) Connect a second cable between your pulse generator and the Q-switch trigger TTL BNC on the ETP. This cable will carry the Open Q-switch signals, which will be delayed 100-600 µs from your externally supplied fire flashlamps signals.

3) Place the ETP's Q-switch toggle switch in its **EXT**ernal position.

4) Set the RB601 in **AUTO** mode and select **PGM #2**. Press the **ACTIVATE** key but **DO NOT** press the **START** button.

Precision II series chronograph.



5) Begin sending pulses to the EXT flashlamp trig in BNC at the normal repetition rate of the Precision II. These fire flashlamps signals should start the flashlamps.

CAUTION:

Do not exceed the nominal repetition rate of the laser. Lensing effects from higher repetition rates can damage laser optics.

6) Now start sending pulses to the Q-switch trigger TTL BNC. Initially send these Open Q-switch signals ~200 µs after each fire flashlamp signal.

7) Press the **SHUTTER** button on the RB601 and verify that the shutter LED is on. The Precision should now output laser pulses ~80 ns after each open Q-switch signal, depending on the laser's buildup time (BUT).

8) Adjust the timing delay between the flashlamp fire and open Q-switch pulses for maximum (or any desired) laser energy.

Note:

An additional signal to start the flashlamp capacitor banks recharging is not necessary in DAT mode.

2) Stanford Research Pulse Generator setup

Directions for External Triggering Precision II using a Stanford Delay Generator Mdl#DG535.

It is not possible to externally trigger the flashlamps and have the laser internally trigger the Q-switch. You must provide both a lamp fire and Q-switch fire command.

Materials required

1 ea. Stanford Delay Generator MDL# DG535

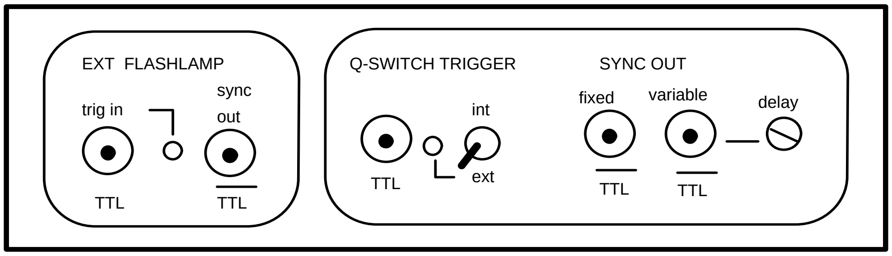
2 ea. Standard BNC cables.

Procedure:

1. Program the DG535 as follows:

a) TRIGGER - set to Internal and desired reprate (10, 20, 30 or 50 Hz)

b) OUTPUTS - set all outputs to High Z, TTL and NORMAL



External Trigger Panel (ETP) found on side of bench.

c) DELAYS :

1. A = T + 0
2. B = A + 10 µs
3. C = A + 200 µs
4. D = C + 10 µs

2. Start up the Powerlite as follows.

   a. Turn On Key switch
   b. Select AUTO and Activate PGM#2
   c. DO NOT press the START key

3. Locate the External Trigger Panel (ETP) on oscillator side of laser bench.

4. Connect a BNC cable between the AB positive going output(0V to 4V for 10 µs) of the DG535 and the EXT FLASHLAMP Trig In connector on the ETP.

Note:

The laser flashlamps should start flashing at reprate set on a DG535. The red LED on the ETP next to the Trig In connector should come on.

5. Flip Q-SWITCH TRIGGER toggle on ETP to “ext” position.

Note:

The red LED on the ETP next to the EXT connector should come on.

6. Connect a BNC cable between the CD positive going output (0V to 4V for 10µs) of the DG535 and the Q-SWITCH TRIGGER BNC connector on the ETP.

Warning:

Laser output should occur at next step.

7. On the Powerlite remote box press on the SHUTTER button. The laser should now lase. If no lasing is observed increase “C” delay until lasing is observed.

8. Adjust the Delay of “C” on the DG535 to maximize laser power. Optimum “C” delay is normally between 200 µs and 1µs.

3) Remote RS232 operation

The CU601C can be controlled through the front panel RS232 D25 connector.

The RS232 control can be accomplished by interfacing an appropriate cable between the CU601C and a host computer (see RS232 signals in demo program on page 2-17 of this section). The remote box may be removed from the CU601C if a control program is running on the host computer. If the remote box is left plugged in, it will display the activities of the CU601C while under control of the host computer. During power up reset, the CU601C will “hunt” for an active controller (either the remote box or the host RS232 computer). The CU601C will first look for a RS232 host computer and then begin communications, if none is found it will look for the remote box, if none is found then the CU601C will “time out”. The RS232 controller must send a “keep alive” signal back to the CU601C or else it will time out in approximately 5 seconds and default to a “warm reset” state. When the remote box is the only controller, it takes care of this “keep alive” (any character) with its own internal microcomputer, unless the remote box is placed into the **REMOTE** mode on RB601. The “keep alive” function is a safety feature to guarantee that there is always some means of controlling the laser system.

a) Command protocol

The host computer control program sends command bytes to the CU601C. These command bytes duplicate all of the keyboard keys on the remote box. The following is a list of the command bytes:

Command byte (hex)	**Command Description**
011H	PROGRAM INCREMENT
021H	PROGRAM DECREMENT
031H	STORE
041H	ACTIVATE
012H	PARAMETER INCREMENT

022H	PARAMETER DECREMENT
032H	PARAMETER SELECT
042H	RESET
013H	SHUTTER
023H	REMOTE/LOCAL
033H	CHARGE
043H	FIRE
014H	Q-SWITCH ON/OFF
024H	AUTO/MANUAL
034H	START
044H	STOP
015H	HARMONIC GENERATOR #1 CW
025H	HARMONIC GENERATOR #1 CCW
035H	HARMONIC GENERATOR #2 CW
045H	HARMONIC GENERATOR #2 CCW

There are two special command bytes that are sent back to the host computer and allow it to see the status of the CU601C. The first command is:

Command (hex)	Command Description
003H	RETURNS PROGRAM STATUS

When this command is sent to the CU601C, it sends back active program status in six ASCII strings separated by a line feed and a carriage return. The program parameter "ACTIVE PARAMETER" listed below refers to parameter in which the laser is operating at any given time. If there are 2 PU's with the laser, then "LAST PU" refers to PU2. "MODE" refers to remote or local mode. The six strings are returned in the following format:

Program Parameter	String Format
REP RATE	4 BYTES+CR+LF
Q-SWITCH DELAY	4 BYTES+CR+LF
PULSE DIVISION	4 BYTES+CR+LF
SHOT COUNT	8 BYTES+CR+LF
BAUD RATE	5 BYTES+CR+LF
ACTIVE PARAMETER	1 BYTE +CR+LF
LAST PU	1 BYTE+CR+LF
MODE	1 BYTE+CR+LF

The other special command is:

Command (hex)	Command Description
004H	RETURNS CU601C STATUS

When this command is sent to the CU601 it sends back the "CU601C status" in a 10 byte ASCII string followed by a carriage return. The status byte is returned in the following format:

```
bbbbbbbbbb+CR+ LF  = 10 bytes total
||||||||||_____________SHUTTER  0=CLOSED, 1=OPEN
|||||||||______________EOC 4 0=NOT CHARGED,1=CHARGED
||||||||_______________EOC 3 0=NOT CHARGED,1=CHARGED
|||||||________________EOC 2 0=NOT CHARGED,1=CHARGED
||||||_________________EOC 10=NOT CHARGED, 1=CHARGED
|||||__________________H GEN#2 CCW 0=NOT LIMIT,1=LIMIT
||||___________________H GEN#2  CW 0=NOT LIMIT,1=LIMIT
|||____________________H GEN#1 CCW 0=NOT LIMIT,1=LIMIT
||_____________________H GEN#1  CW 0=NOT LIMIT,1=LIMIT
|______________________Q-SWITCH  0=NOT ACTIVE 1=ACTIVE
```

b) RS232 specification/baud rate

The specifications for the RS232 channel are:

```
[xxxxx],N,8,1
   |    | | |____ 1 STOP BIT
   |    | |______ 8 DATA BITS
   |    |________ NO PARITY
   |______________BAUD RATE SELECTABLE FROM:
                     110
                     150
                     300
                     600
                    1200
                    2400
                    4800
                    9600  (DEFAULT)
                   19200
```

c) RS232 signals

The RS232 connector on the front panel is a D25 female connector. The following signals that are important for RS232 control are listed below:

RS232 pin	Pin Description
2	TxD (transmit data)
3	RxD (receive data)
4	RTS (request to send)
5	CTS (clear to send)
7	SIGNAL COMMON

A typical interface cable for RS232 interface between a PC or equivalent and the CU601C is as follows:

```
                    CU601C                    RS232

                     TxD 2|——————————————>|3RxD
                     RxD 3<————————————————|2TxD
                     RTS 4|—|           |—|5 CTS
                     CTS 5|—|           |—|4 RTS
          SIGNAL COMMON 7|————-----——————|7 SIGNAL COMMON
                         |              |—|6 DSR
                         |              |—|20 DTR
                    D25 MALE        D25 FEMALE
                    CONNECTOR       CONNECTOR
```

Pins 4 & 5 on the CU601C end are tied together. It is also recomended to tie together pins 4 & 5 and pins 6 & 20 on the PC end.

A typical interface cable for RS232 interface and the CU601C is in the example below:

```
                         CU601C                    RS232

                       TxD 2 |——————————————————>|2
                       RxD 3 |<——————————————————|3 TxD
                       RTS 4 |—|              |—|8 CTS
                       CTS 5 |—|              |—|7 RTS
         SIGNAL COMMON 7 |————-----——————|5 SIGNAL COMMON
                             |              |—|6 DSR
                             |              |—|4 DTR

                      D25 MALE             D9 FEMALE
                     CONNECTOR             CONNECTOR
```

Pins 4 & 5 on the CU601C end are tied together. It is also recomended to tie together pins 7 & 8 and pins 4 & 6 on the PC end.

d) Host computer demo program

Listed below is a demo control program to control the CU601C through the RS232 channel. The program was written in Microsoft QUICK BASIC and run on a PC or equivalent. Your PC must have a serial card installed, an RGB display card (or equivalent) and a 360 K floppy disk. An RS232 cable, as described in part c, must be installed between the CU601C and the computer.

```
100 '**************************************************************************
105 '*    CONTINUUM/SANTA CLARA, CA                          *
110 '*    SOFTWARE RS232 COMMUNICATION DEMO FROM IBM-PC*
120 '*    TO CU601 LASER COMPUTER.                           *
130 '*    AUTHOR:  RAY PARKER  1-21-88                       *
135 '*    LANGUAGE: MICROSOFT QUICK BASIC 4.5                *
136 '*    REVISED: 6/29/90 R. PARKER                         *
140 '**************************************************************************
```

```
1000 CLS
1010 OPEN “COM1:9600,N,8,1” FOR RANDOM AS #1
1020 GOSUB 2000                    ‘DISPLAY MENU
1025 GOSUB 3100:GOSUB 3180:GOSUB 3500:GOSUB 3520  ‘GET STA-
TUS/CU STATUS
1027 LOCATE 11,1:PRINT”                  “;
1030 LOCATE 11,1:COLOR(15)
1031 PRINT”ENTER COMMAND”;
1032 COLOR(15+16):PRINT”>”
1041 COLOR 15:LOCATE 11,15:PRINT CMD$;
1042 IF CMD$<>”” THEN IF ASC(CMD$)>90 THEN
CMD$=CHR$(ASC(CMD$)-32)  ‘CONVERT TO UPPER CASE
1045 LOCATE 25,15:COLOR 0,7
1050 IF CMD$=”S” THEN PRINT”TOGGLE SHUTTER
“;:CMD=19:SOUND 1200,.2:GOSUB 3000
1060 IF CMD$=”C” THEN PRINT”CHARGE LASER
“;:CMD=51:SOUND 1200,.2:GOSUB 3000
1070 IF CMD$=”F” THEN PRINT”FIRE LASER      “;:CMD=67:SOUND
1200,.2:GOSUB 3000
1080 IF CMD$=”B” THEN PRINT”BEGIN AUTO FIRE
“;:CMD=52:SOUND 1200,.2:GOSUB 3000
1090 IF CMD$=”E” THEN PRINT”END AUTO FIRE
“;:CMD=68:SOUND 1200,.2:GOSUB 3000
1100 IF CMD$=”M” THEN PRINT”AUTO/MANUAL MODE
“;:CMD=36:SOUND 1200,.2:GOSUB 3000
1110 IF CMD$=”G” THEN PRINT”Q-SWITCH ON/OFF
“;:CMD=20:SOUND 1200,.2:GOSUB 3000
1120 IF CMD$=”R” THEN PRINT”RESET          “;:CMD=66:SOUND
500,.5:GOSUB 3000
1130 IF CMD$=”W” THEN PRINT”ROTATE HGEN 1 CW
“;:CMD=21:GOSUB 3000

1135 IF CMD$=”Y” THEN PRINT”ROTATE HGEN 2 CW
“;:CMD=53:GOSUB 3000
1140 IF CMD$=”V” THEN PRINT”ROTATE HGEN 1 CCW
“;:CMD=37:GOSUB 3000
1145 IF CMD$=”K” THEN PRINT”ROTATE HGEN 2 CCW
“;:CMD=69:GOSUB 3000
1150 IF CMD$=”P” THEN PRINT”PROGRAM STATUS   “;:SOUND
1000,.5:GOSUB 3100:GOSUB 3180
1160 IF CMD$=”U” THEN PRINT”CU 601 STATUS    “;:SOUND
1000,.5:GOSUB 3500:GOSUB 3520
1170 IF CMD$=”J” THEN PRINT”PARM SELECT
“;:CMD=50:SOUND 1200,.2:GOSUB 3000
1180 IF CMD$=”I” THEN PRINT”INC PARAMETER
“;:CMD=18:GOSUB 3000
1190 IF CMD$=”D” THEN PRINT”DEC PARAMETER
“;:CMD=34:GOSUB 3000
1191 IF CMD$ =“A” THEN PRINT “INC PROGRAM”;: CMD = 17:
```

```
GOSUB 3000
1192 IF CMD$ =“Z” THEN PRINT “DEC PROGRAM”LL CMD =
33:GOSUB 3000
1193 IF CMD$ =“K” THEN PRINT “STORE”;: CMD = 49: GOSUB 3000
1194 IF CMD$ =“L” THEN PRINT “ACTIVATE”;: CMD = 65: GOSUB
3000
1200 IF CMD$=”Q” THEN STOP
1300 GOSUB 3900                    ‘KEEP ALIVE DELAY
1999 GOTO 1030

2000 ‘******* DISPLAY MENU ********
2005 CLS:COLOR 15,0
2010 PRINT”CONTINUUM - CU601 HOST INTERFACE
COMMANDS”+STRING$(26,32);
2015 COLOR 15,0
2020 PRINT STRING$(80,205)
2025 COLOR(7)
2030 PRINT”<C> CHARGE        <W> ROTATE HGEN 1 CW       <J>
PARM SELECT” <G> Q-SWITCH TOGGLE”
2040 PRINT “<F> FIRE                <V> ROTATE HGEN 1 CCW  <I>
INC PARM    <S> SHUTTER TOGGLE”
2050 PRINT “<B> START AUTO MODE     <Y> ROTATE HGEN 2 CW
<D> DEC PARM       <A> INC PROGRAM “
2060 PRINT “<E> STOP AUTO MODE      <K> ROTATE HGEN 2 CCW
<K> STORE    <Z> DEC PROGRAM
2070 PRINT “<M> MANUAL/AUTO         <R> RESET    <L> ACTI-
VATE
2085 COLOR(15)
2090 PRINT STRING$(80,205)
2091 COLOR(7)
2095 PRINT”<Q> QUIT”       <P> PROGRAM STATUS    <U> CU601
STATUS”

2097 COLOR 0,7:LOCATE 25,1:PRINT “LAST
COMMAND:”+STRING$(67,32);
2098 COLOR 7,0
2099 LOCATE 11,1:COLOR 31:PRINT”PRESS REM/LOC KEY!”;
2100 RETURN

3000 ‘******* SEND BYTE RS-232 *********
3010 PRINT #1,CHR$(CMD);
3030 RETURN
3100 ‘******* RECEIVE PROGRAM STATUS ***********
3110 CMD=3:GOSUB 3000    ‘send progstat cmd
3111 IF LOC(1)=0 THEN GOTO 3110
3120 REPRATE$=INPUT$(12,#1)
3130 TRIGDELAY$=INPUT$(12,#1)
3140 PULSEDIV$=INPUT$(12,#1)
3150 SHOTCOUNT$=INPUT$(12,#1)
3160 BAUDRATE$=INPUT$(12,#1)
3170 ACTPARM$=INPUT$(12,#1)
```

```
3173 LASTPU$ = INPUT$(12,#1)
3174 CUSTAT$ = INPUT$(12,#1)
3176 RETURN

3180 '***** DISPLAY PROGRAM STATUS ***
3190 LOCATE 13,1:COLOR(15)
3195 PRINT "PROGRAM STATUS"
3196 PRINT STRING$(30,196)
3197 COLOR(15)
3200 PRINT "REP RATE    :";LEFT$(REPRATE$,10);" Hz"
3210 PRINT "Q-SW DELAY  :";LEFT$(TRIGDELAY$,10)+" uS"
3220 PRINT "PULSE DIV   :";
3226 PRINT LEFT$ (PULSEDIV$, 10); "       "
3230 PRINT "SHOT COUNTER:";LEFT$(SHOTCOUNT$,10);" shots"
3240 PRINT "BAUD RATE   :";LEFT$(BAUDRATE$,10);" baud"
3245 PRINT "ACTIVE PARM :";" ["+MID$(ACTPARM$,10,1)+"]";
3251 A$=MID$(ACTPARM$,10,1)
3252 IF VAL(A$)<1 THEN PRINT"           "
3253 IF A$="1" THEN PRINT" REP RATE  "
3254 IF A$="2" THEN PRINT" Q-SWITCH  "
3255 IF A$="3" THEN PRINT" PULSE DIV "
3256 IF A$="4" THEN PRINT" SHOT COUNT"
3257 IF A$="5" THEN PRINT" BAUD RATE "
3258 IF A$="6" THEN PRINT" Q-SWITCH2 "
3259 COLOR(15)
3260 PRINT "CU MODE   :"; LEFT$(CUSTAT$,10)
3261 PRINT "LAST PU     :"; LEFT$(LASTPU$, 10)
3265 PRINT STRING$(30,196)
3270 COLOR(7)
3300 RETURN

3500 '******* RECEIVE CU STATUS ********
3510 CMD=4:GOSUB 3000
3511 IF LOC(1)=0 THEN GOTO 3511
3515 BUF$=INPUT$(12,#1)
3517 RETURN

3520 '****** DISPLAY CU STATUS *******
3530 OS=-4: COLOR (15)
3540 LOCATE 14+OS,41:PRINT "CU601 STATUS"
3542 LOCATE 15+OS,41:PRINT STRING$(30,196)
3543 COLOR(15)
3545 LOCATE 16+OS,41:PRINT "STATUS BYTE     : ";BUF$;
3550 LOCATE 17+OS,41
3560 IF MID$(BUF$,10,1)="0" THEN PRINT"SHUTTER          : CLOSED"
ELSE PRINT"SHUTTER          : OPEN  "
3565 LOCATE 18+OS,41
3566 IF MID$(BUF$, 1, 1) = "1" THEN PRINT "Q-SWITCH: ACTIVE
"ELSE PRINT "Q-SWITCH:  NOT ACTIVE
3567 LOCATE 19+ OS, 41
```

```
3570 IF MID$(BUF$,2,1)=”1" THEN PRINT”HGEN 1 CW LIMIT : YES   “
ELSE PRINT”HGEN 1 CW LIMIT : NO   “
3575 LOCATE 20+OS,41
3580 IF MID$(BUF$,3,1)=”1" THEN PRINT”HGEN 1 CCW LIMIT: YES   “
ELSE PRINT”HGEN 1 CCW LIMIT: NO   “
3585 LOCATE 21+OS,41
3586 IF MID$(BUF$,4,1)=”1" THEN PRINT”HGEN 2 CW LIMIT : YES   “
ELSE PRINT”HGEN 2 CW LIMIT : NO   “
3587 LOCATE 22+OS,41
3588 IF MID$(BUF$,5,1)=”1" THEN PRINT”HGEN 2 CCW LIMIT: YES   “
ELSE PRINT”HGEN 2 CCW LIMIT: NO   “
3589 LOCATE 23+OS,41

3590 IF MID$(BUF$,6,1)=”1" THEN PRINT”EOC 1         : YES   “ ELSE
PRINT”EOC 1         : NO   “
3595 LOCATE 24+OS,41
3600 IF MID$(BUF$,7,1)=”1" THEN PRINT”EOC 2         : YES   “ ELSE
PRINT”EOC 2         : NO   “
3605 LOCATE 25+OS,41
3610 IF MID$(BUF$,8,1)=”1" THEN PRINT”EOC 3         : YES   “ ELSE
PRINT”EOC 3         : NO   “
3615 LOCATE 26+OS,41
3620 IF MID$(BUF$,9,1)=”1" THEN PRINT”EOC 4         : YES   “ ELSE
PRINT”EOC 4         : NO   “
3695 LOCATE 27+OS,41:COLOR(15)
3700 PRINT STRING$(30,196);
3705 COLOR(15)
3799 RETURN

3900 ‘************* KEEP ALIVE DELAY **************
3910 FOR DELAY =1 TO 1500   ‘1 SEC DELAY
3920 CMD$=INKEY$
3930 IF CMD$<>”” THEN RETURN
3940 NEXT DELAY
3950 CMD=6:GOSUB 3000   ‘SEND KEEP ALIVE
3960 RETURN
```

F. Installation

Inspection after shipment

Check crates and boxes for damage before uncrating the laser. Take note of all visible external damage (scratches, dents, etc.).

Remove the laser cover. Inspect the inside of the laser for loose parts. Do not touch any part inside the laser.

If damaged, please notify as soon as possible both the carrier and Continuum. No attempt should be made by the purchaser to start up the laser prior to installation by Continuum personnel. Damage occurring due to usage before installation will not be covered under our warranty.

Installation requirements

Install the laser in a closed and clean location. Lasers work best in a temperature stabilized environment. Therefore it is advisable to use the laser in an air conditioned room, placed so that no vents blow directly on the laser and the laboratory temperature does not exceed 85° F. The laser should be mounted on a solid work table. In choosing a place for your laser, keep in mind that access should be available from all sides and the remote control box within reach of the user.

Choose a location for the power supply cabinet such that:

- the back panel of the cabinet is not more than 10 feet away from where the umbilical exits the laser.
- the back panel of the cabinet is at least 2 feet from a wall for easy access during installation and maintenance.
- each side of the cabinet is at least 8 inches away from the wall or other obstacle to allow an unobstructed air flow to the power supply.

Power and water service

We recommend these system requirement levels even though normal system use will be considerably below these levels.

- Power is to be 208 V to 240 V, 50/60 Hz, 3 phase, at 20 amperes per phase or 200 to 250 V, 50/60 Hz single phase breakered at 20 A per phase
- City water to cool the laser should supply 3 gallons per minute at a pressure not to exceed 70 psi. Connectors for ½" ID hose should be supplied to connect the hoses to the supply and drain.

Equipment and materials requirements:

- distilled water, 3 gallons (10 liters), 1 MΩ/cm or better (Water from a glass distiller will meet this requirement)
- 50 ml methanol, reagent grade or better (for cleaning optics)
- laser safety glasses for the fundamental, infrared and its harmonics
- burn or footprint paper, Kodak linagraph paper standard type 1895, catalog # 198-6009
- power meter with **volume** absorbing detector.

Possible sources for power meter

Scientech, Boulder, Colorado
Diamond Ophir, North Reading, Mass.
Gentec, Ste-Foy, Quebec
Molectron, 7470 S.W. Bridgeport Rd.,
Portland, OR 97224. Tel: (800) 366-4340

- oscilloscope, with a bandwidth of 350 MHz or better and a enhanced view screen for viewing 5 ns/Div traces.

Possible sources for oscilloscope

Tektronix, Beaverton, Oregon (mdl #2467)
LeCroy, Chestnut Ridge, New York

- IR phosphor card

Possible sources for IR phosphor card

Kodak, Rochester, New York
Quantex, Rockville, Maryland

- Photodiode with rise time <1 ns
  Precision Applied Science, Ann Arbour, Michigan
  Call Continuum Service, Santa Clara, California.
  Tel: 1+(408) 727-3240

System installation

The installation of the laser will be performed by a Continuum representative at a date agreed upon between the user and Continuum at the time of delivery.

The installation will consist of:

a) Hooking up the laser to the water and electricity.

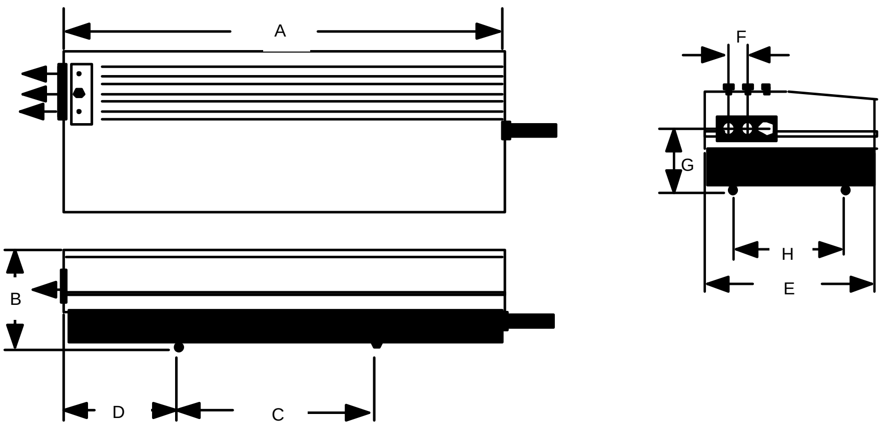
b) Demonstration of system turn-on and operation.

c) Explanation of routine maintenance procedures.

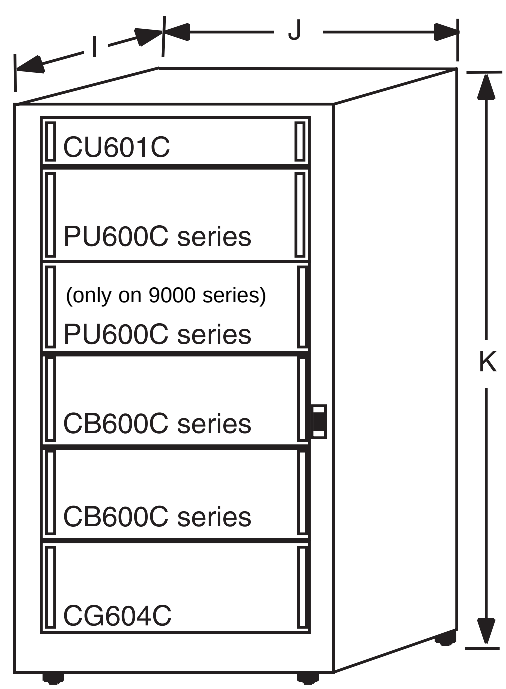
d) Measure energy output of the system.

e) Performance of additional acceptance tests as specified in purchase order. Shot-to-shot performance will be demonstrated if storage oscilloscope is made available.

See cover letter for details.



14 unit cabinet (8000)
18 unit cabinet (9000)



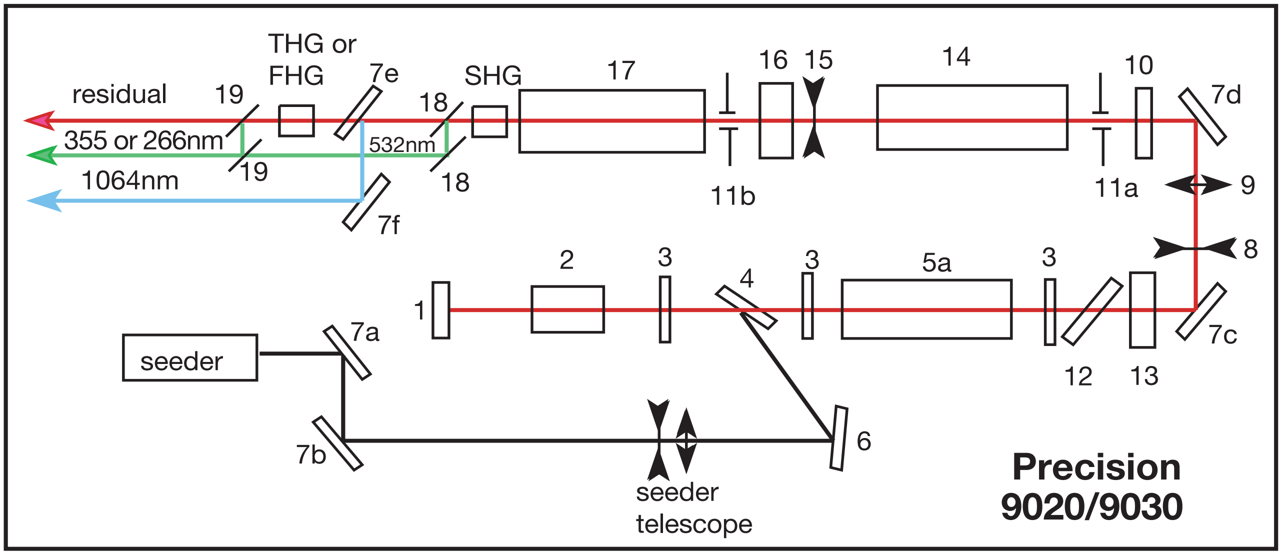
Precision II physical dimensions.

All dimensions in mm (inches)

Precision II series	A	B	C	D	E	F	G	H	I	J	K
All models	1189.2 (46.82)	298.4 ±12 (11.75 ±.5)	696 (27.41)	236.06 (9.29)	457.2 (18)	40 (1.57)	165 (6.5)	251 (9.88)	714.5 (28.13)	621 (24.46)	921.6 (36.31) 9000 720.9 (28.35) 8000

Chapter III Subassemblies & Module Descriptions Contents

Chapter III Laser Bench Optics & Electronics Contents



Legend for Precision 9010, 9020 & 9030

1. Mirror, rear, (rep rate dependent)
2. Pockels cell, 202-0003
3. λ/4 plate, 108-0001
4. Dielectric polarizer, 199-0116

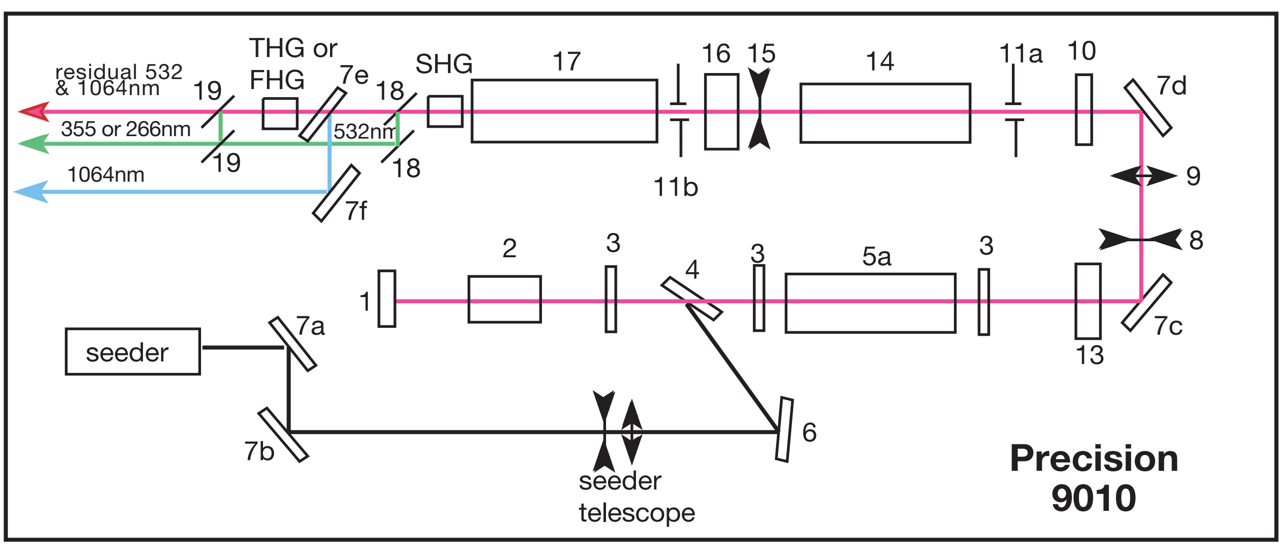
5a. 811U-06 head, 507-0700
(for 10, 20 & 30Hz)
rod, 6mm, 201-0056
flashlamp, 203-0019

6. Mirror, turning, 30°, 105-0086
7. Mirror, turning, 45°, 105-0002
8. Div. lens, -104mm, 102-0005
9. Con. lens, +155mm, 101-0001
10. λ/2 plate, 108-0004

11a. Pinhole, 9.0mm, 314-0176

11b. Pinhole, 9.5mm, 314-0317

12. Dielectric polarizer, 199-0055
13. Output coupler, (rep rate dependent)
14. 811D-09 head, 507-0770
rod, 9mm, 201-0005
flashlamp, 203-0036
15. Div. lens, rep rate dependent
16. Rotator, quartz, 199-0067
17. 811U-09 head, 507-0750
rod, 9mm, 201-0005
flashlamp, 203-0036
18. Dichroics, 532nm, 105-0022
19. Dichroics. 355nm, 105-0023
or 266nm, 105-0025



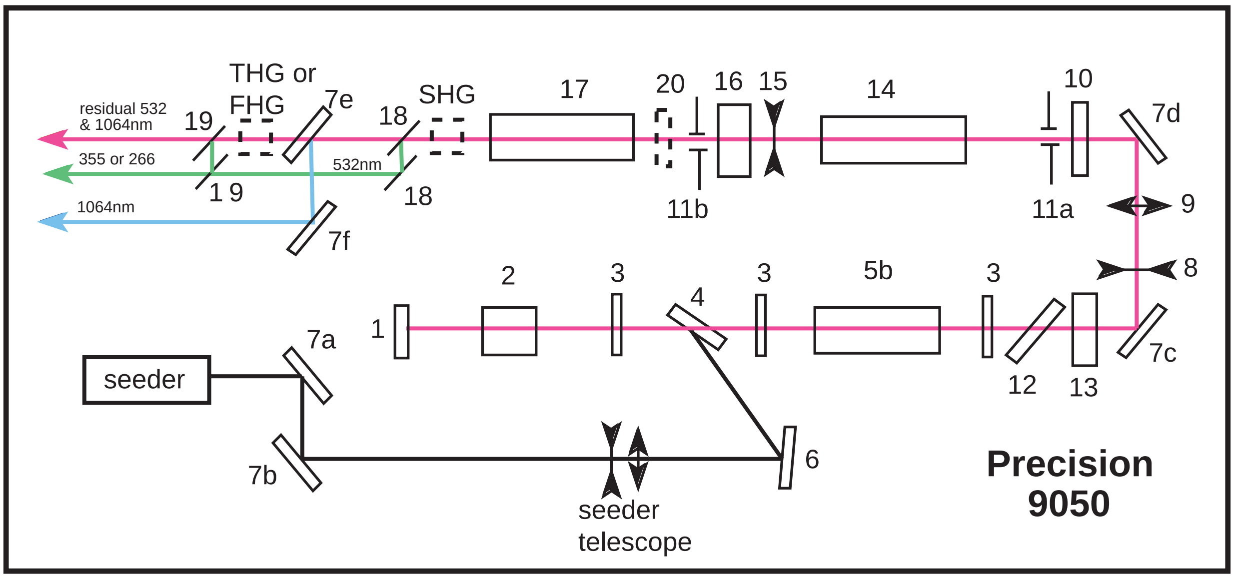
Chapter III Subassemblies & Module Descriptions

A. Laser bench optics

1. Optical layouts

In this section the optics are shown positioned on the laser bench accompanied by many of their part numbers for easy reference. For the Precision II 8000 series layouts, please turn to the beginning of Chapter II.

Shown here are the Precision II layouts, 9010, 9020, 9030 & 9050.



Legend for Precision 9050

1. Mirror, rear, (rep rate dependent)
2. Pockels cell, 202-0003
3. λ/4 plate, 108-0001
4. Dielectric polarizer, 199-0116

5b. 811U-05 head, 507-1700
  (for 50 Hz)
  rod, 5mm, 201-0094
  flashlamp, 203-0019

6. Output coupler, (rep rate dependent)
7. Mirror, turning, 45°, 105-0002
8. Div. lens, -91.4mm, 102-0002
9. Con. lens, +155mm, 101-0001
10. λ/2 plate, 108-0004

11a. Pinhole, 9.0mm, 314-0176
11b. Pinhole, 9.5mm, 314-0317

12. Dielectric polarizer, 199-0055
13. Output coupler, (rep rate dependent)
14. 811D-09 head, 507-0770
  rod, 9mm, 201-0005
  flashlamp, 203-0032
  (for 9050 only)
15. Div. lens, rep rate dependent
16. Rotator, quartz, 199-0067
17. 811U-09 head, 507-0750
  rod, 9mm, 201-0005
  flashlamp, 203-0032
18. Dichroics, 532nm, 105-0022
19. Dichroics. 355nm, 105-0023
  or 266nm, 105-0025
20. Lens, cyl., (rep. rate dependent)

2. Laser heads

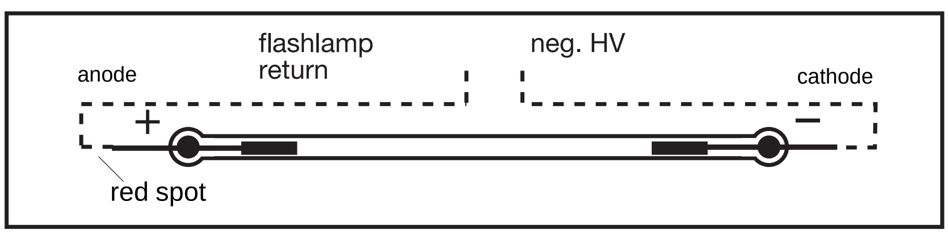
General description

Continuum's Precision II laser series utilizes several basic head models. They are the 811U-05, -06, -07 & -09 with the flashlamp in the "upper" position, the 811D-09 with the flashlamp in the "down" position and the 812H and 812V with their flashlamps in the "horizontal" and "vertical" positions. The laser heads are located on the laser bench and are utilized as either oscillator or amplifiers.

Each laser head is of modular design incorporating a rod, a flashlamp and coupling medium. All have linear flashlamps which are in a close coupled configuration surrounded by a high brilliance magnesium oxide diffuser. This results in a high pumping efficiency that minimizes thermal loading and reduces power consumption. These features combine to create the excellent pumping homogeneity required for producing high gain, superior quality beams.

Rods

The heads are designed to pump Nd+3 doped YAG. The doping levels vary from 0.6 to 1.4%. The YAG rod ends have hard dielectric anti-reflective coating (AR). The rod length for all Precision series heads is 115 mm measured along the optical axis. The diameter of the rod is designated by the head model number. For example the 811U-06 has a 6 mm diameter rod, the -09 has a 9 mm diameter rod.

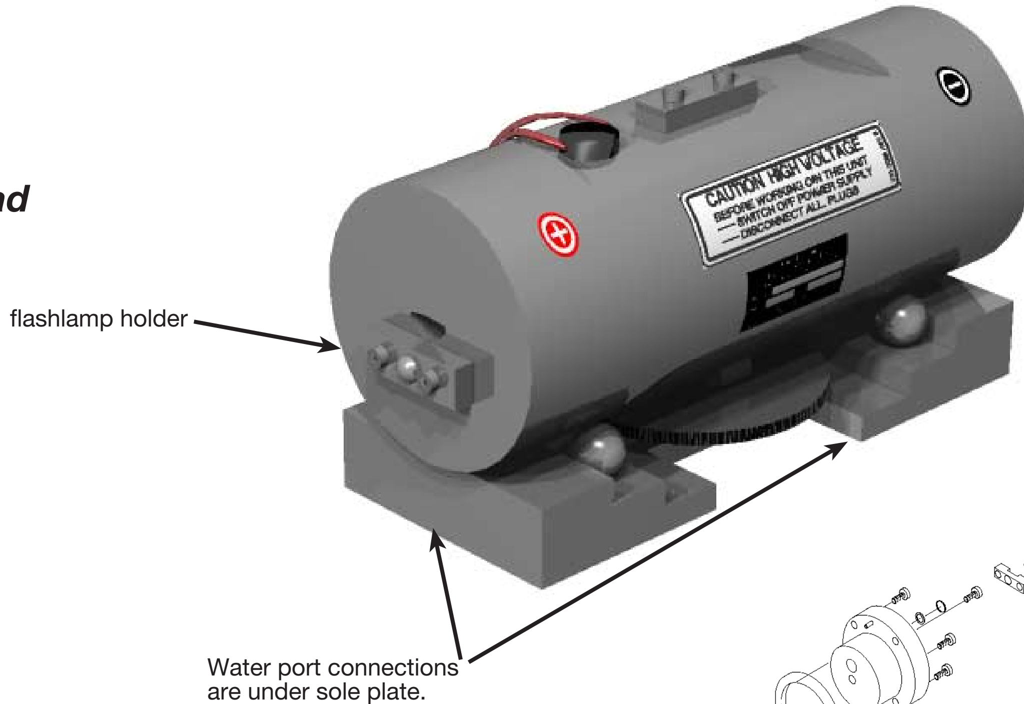


Flashlamps

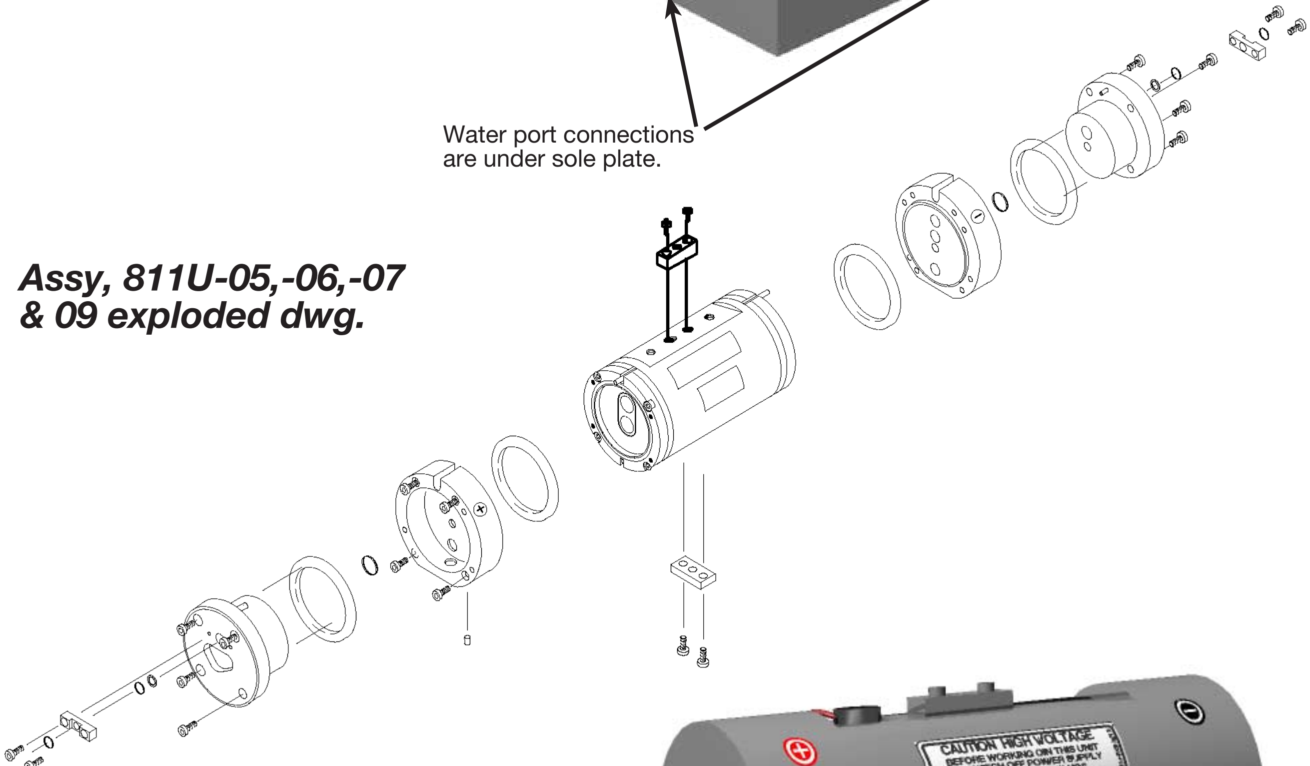
The Precision II series heads are pumped by linear flashlamps. These lamps have a voltage polarity that must be observed. The anodes of the flashlamps can be identified by a red marking on the lamp electrode whereas the cathodes have no markings. The discharge system of the flashlamps use a negative critically damped pulse (-1.8 kV max) with a duration of 200 microseconds full width half max (FWHM). The gas in the flashlamps is xenon with a pressure of 1-3 atmospheres.

Beam height

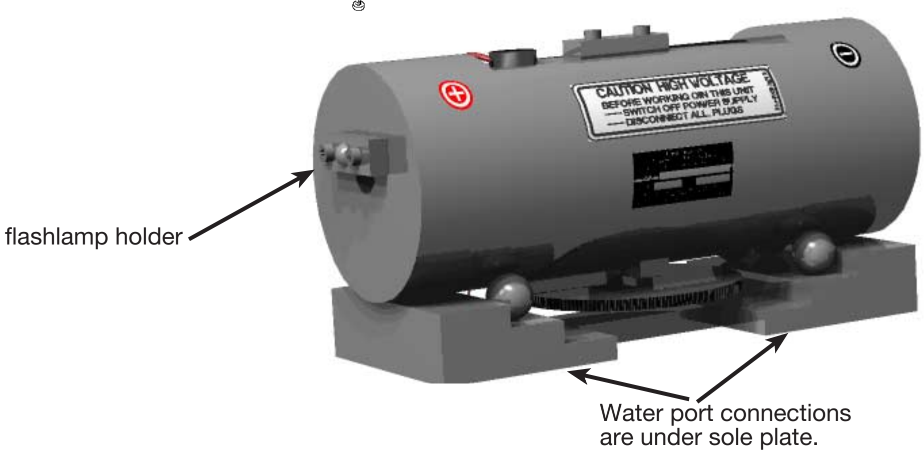
The 811U-05, -06 and -09 heads are designed for a beam height of 43 mm.



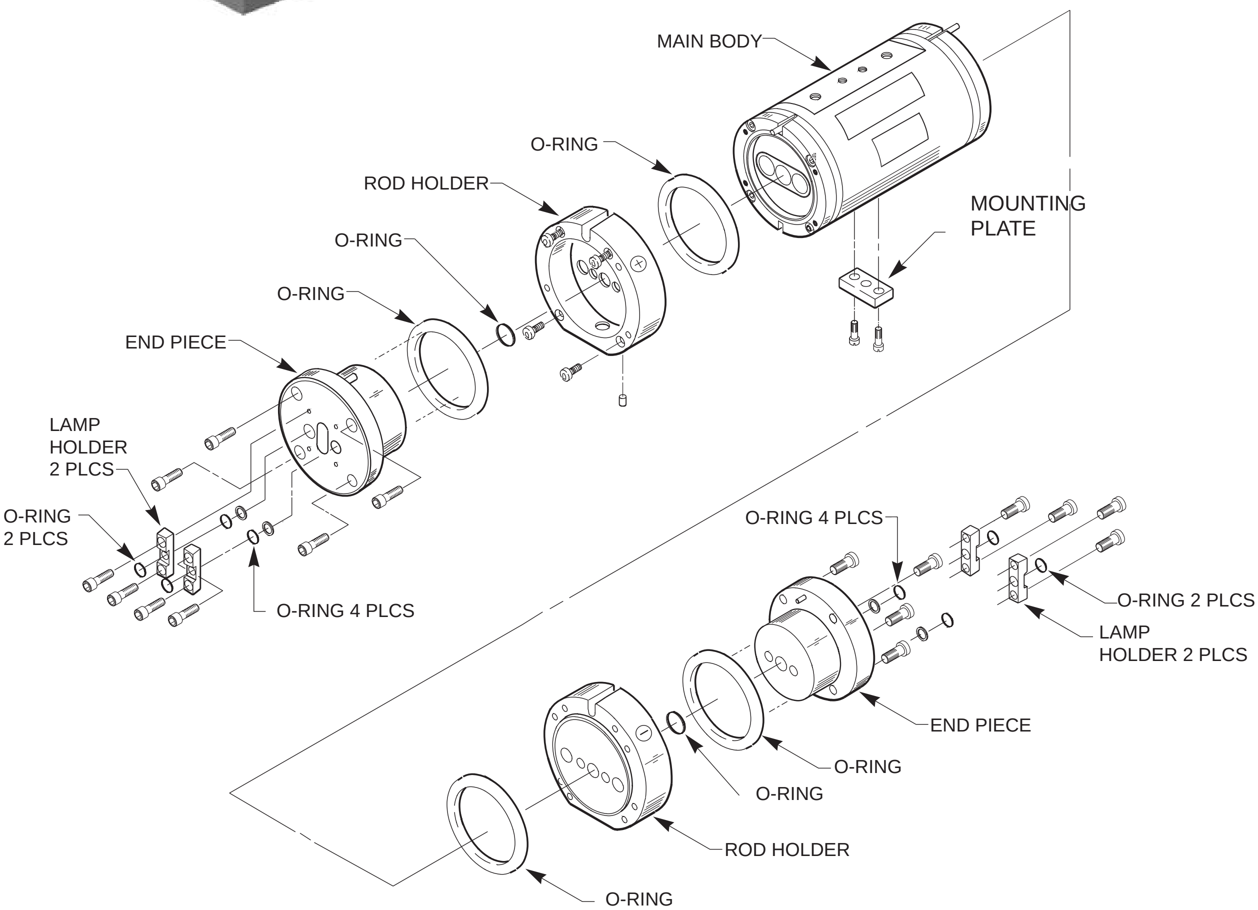
811D-09 head



Assy, 811U-05,-06,-07 & 09 exploded dwg.



811U-05,-06,-07 & 09 head



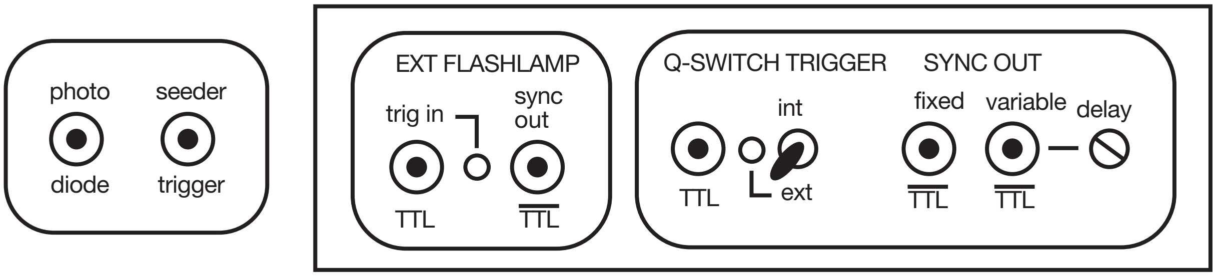
812H-12 head assembly
507-0950

Cooling

Flashlamps and laser rods must be cooled by distilled, deionized water. Resistivity of distilled, deionized cooling water should not fall below 500kΩ/cm. Do not mix any chemical products with the distilled water.

Part numbers for Precision II heads.

Precision II											
Part	**P/N**	**8000**	**8010**	**8020**	**8030**	**8050**	**9010**	**9020**	**9030**	**9050**	**Plus**
811U-05 head assy. cladding only rod flashlamp “O” ring kit	507-1700 507-0725 201-0094 203-0019 507-1705									osc.	
811U-06 head assy. cladding only rod flashlamp “O” ring kit	507-0700 507-0725 201-0056 203-0019 507-0710	osc.			osc. & amp	osc. & amp	osc.	osc.	osc.		osc.
811U-07 head assy. cladding only rod flashlamp “O” ring kit	507-1000 507-0725 201-0004 203-0035 507-1005		osc.	osc.							
811U-09 head assy. cladding only rod flashlamp <50Hz “O” ring kit	507-0750 507-0765 201-0005 203-0036 507-0775						amp.	amp.	amp.	amp.	
811D-09 head assy. cladding only rod flashlamp PL9050 “O” ring kit	507-0770 507-0785 201-0005 203-0032 507-0775						amp.	amp.	amp.	amp.	
812H-12 head assy. cladding only rod flashlamp PL9050 “O” ring kit	507-0950 507-0965 201-0057 203-0032 507-0975										amp.
812V-12 head assy. cladding only rod flashlamp PL9050 “O” ring kit	507-0970 507-0985 201-0057 203-0032 507-0975										amp.
812V-09 head assu. Cladding only rod flashlamp PL9050 "O"ring kit	507-0970 507-0985 201-0057 203-0032 507-0975	amp.	amp.	amp.							



Precision control panel & External Trigger Panel (ETP) found on side of bench.

B. Laser bench electronics

1) Bottom view of laser bench

On the bottom of the laser bench are some electrical connections that are not visible when laser is operating. They are the 750 V board and the crystal oven wiring shown here. Below is a view of the underside of the bench with these components and the positioning of the hoses and umbilical.

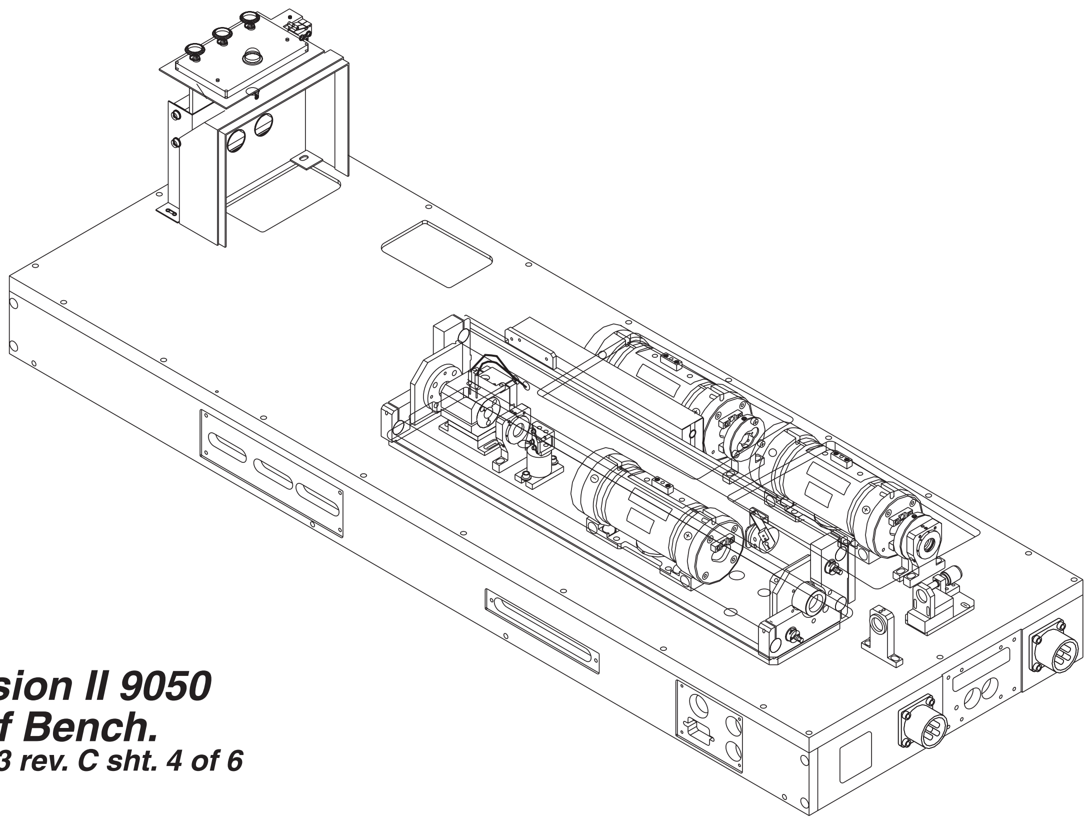
2) Precision II external controls

The CU601C **EXTERNALS** 9-pin ‘D’ connector is routed to the sync panel in the Precision II . This allows direct control of flashlamp and Q-switch firing via BNC connections to TTL level signals. The normal fixed and variable sync functions also appear as TTL level BNC connections on the sync panel.

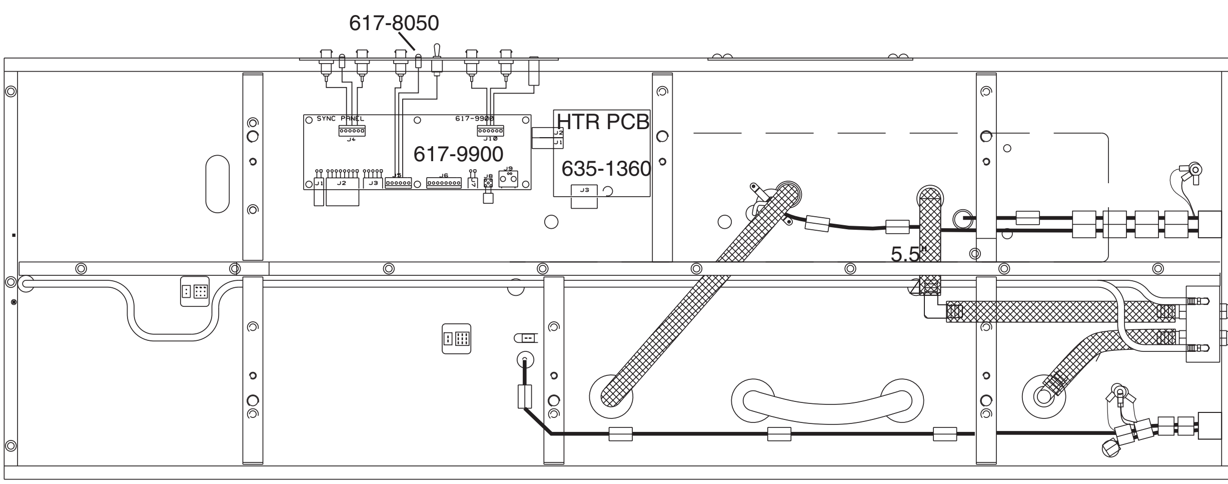
To operate in external mode, the system must be placed in a passive configuration by the remote box or RS232 in order to allow complete control of the laser. In this configuration, the CU601C monitors the status of the system interlocks, and enables laser operation via the keyswitch. It is entirely passive as far as the flashlamp and Q-switch are concerned. (The shot counter is inoperative for externally triggered flashlamp shots.)

a) External flashlamp triggering via the **TRIG IN** BNC — Positive going TTL pulses at 10 Hz or greater repetition rate will commence triggering the flashlamp starting at the second pulse, and will illuminate the red LED **TRIG IN** status indicator. (Repetition rates below 10 Hz are electrically locked out.).

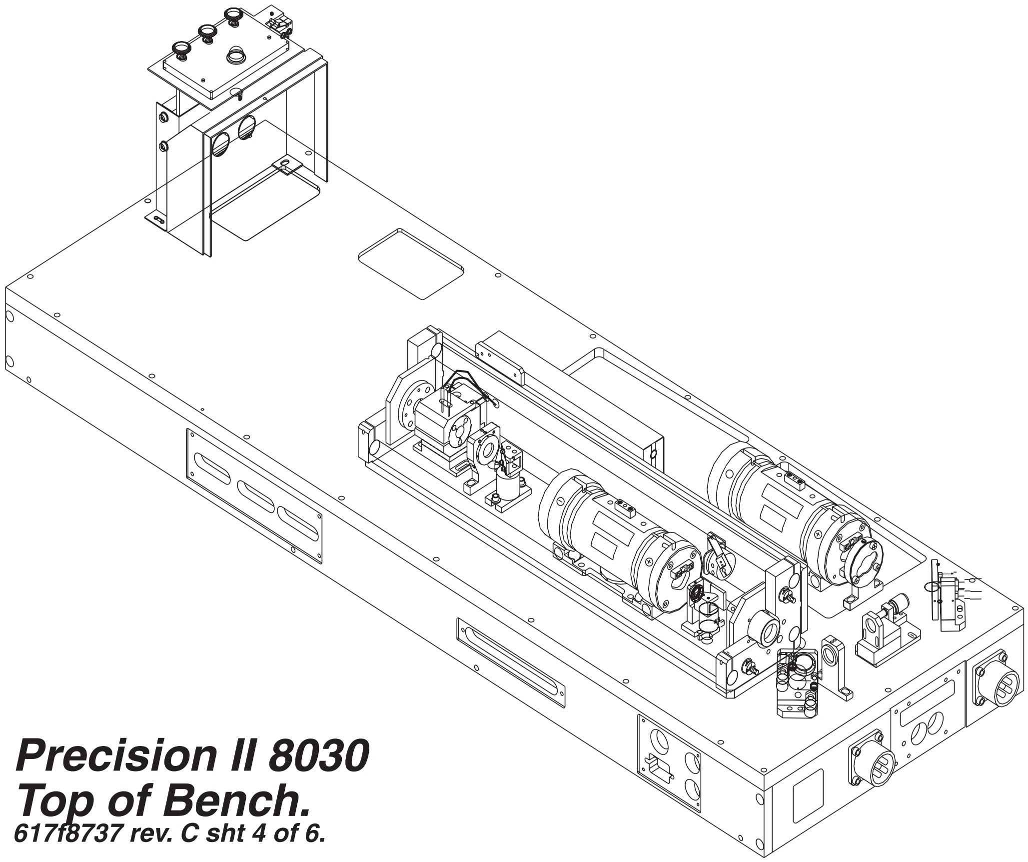
b) Flashlamp sync via the **SYNC OUT** BNC connector — Negative going TTL pulses appear at the BNC connector at the beginning of each actual flashlamp current pulse. The flashlamp sync signal is derived from a toroidal current transformer through which the oscillator flashlamp high voltage lead is passed. The flashlamp sync



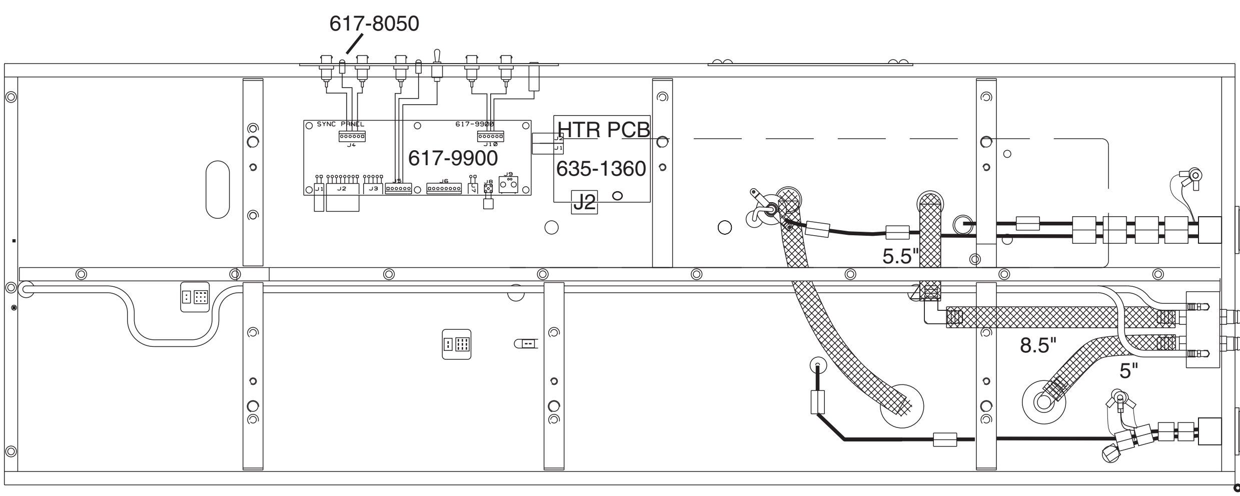
Precision II 9050
Top of Bench.
617f8733 rev. C sht. 4 of 6



Precision II 9050
Underside of Bench
617-8733 rev. C sht 3 of 6.

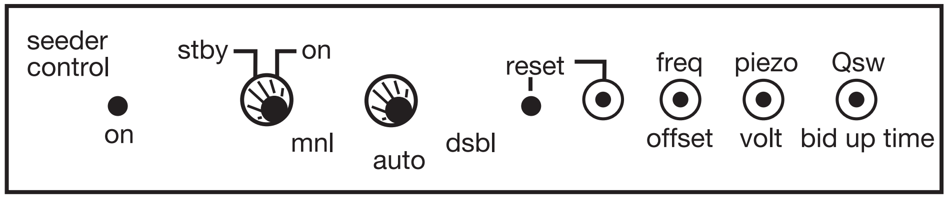


Precision II 8030
Top of Bench.
617f8737 rev. C sht 4 of 6.



Precision II 8030
Underside of Bench.
617-8737 rev. C sht 3 of 6.

Seeder panel on side of bench.



signal is therefore present in **INTERNAL** and **EXTERNAL** flashlamp trigger modes.

c) External Q-switch triggering via the **Q-SWITCH TRIGGER** BNC connector —
Positive going TTL pulses trigger the Q-switch without added delay when the **INT/EXT** switch is in the **EXT** position, illuminating its red LED. **NOTE:** The **VARIABLE** sync function is inoperative in the external Q-switch trigger mode.

d) Fixed sync via the **FIXED/TTL** BNC connector —
The Q-switch trigger signal that drives the laser's Marx bank Pockels cell is buffered, level shifted, and delivered to the BNC connector with minimum delay. It precedes the firing of the Q-switch by approximately 35 ns.

e) The **VARIABLE** sync BNC connector is functional in internal Q-switch trigger mode only. It allows a TTL signal to appear either slightly before or slightly after the firing of the Marx bank Pockels cell driver, with minimum jitter. A screwdriver adjustment is provided to adjust the exact timing desired.

f) **Q-switch ramp up -** when externally triggering a Precision II 9030 or 9050, the external Q-switch signal must start at a delayed level (optimal Q-switch number + 200 µs), then this signal must change to the optimal Q-switch level (~180 µs) at a rate of 10 µs/second. If this procedure is not followed, then optical damage to the laser and downstream optical components may/will occur.

3) Top view of laser bench

Electronics

When looking at the top of the laser bench, the dc motors for the harmonic generators are visible and the Marx bank that drives the Q-switch is shown below. The Marx bank schematic is on page 3-14.

4) Active Q-switch

Principle of Operation

The Q-switch consists of the following:

Optical

a) Pockels cell
b) plate polarizing element
c) quarter-wave plate.

Electrical

a) timed pulse generated by control unit CU601C
b) Marx board (750 V)
c) 750 volt power board.

Pockels cell

The Pockels cell has a longitudinal field KD*P crystal with 15 mm clear aperture mounted at 43 mm beam height. A voltage of ~3600 results in a quarter wave of rotation for photons at 1.06 µm passing in either direction. A voltage of 0 volts results in no rotation.

Plate polarizer

The thin film multilayer dielectric polarizer has an angle of incidence of 57°. In its standard orientation, the polarizer is highly transparent (>95%) to horizontal while being highly reflective (>99%) to vertical. The contrast/extinction ratio is >500:1.

Quarter-wave plate

The plate used introduces a quarter wave rotation to photons at 1.06 µ as they pass in either direction through the plate. The plate has a clear aperture of 15 mm and is mounted at a beam height of 43 mm.

Timed pulse generated by control unit CU601C

The control unit tracks the firing of the flashlamps in the laser head and then at a preselected delay of ~200 µs triggers the Marx board with a +15 V pulse. The signal is normally set to fire at the peak of the gain curve of the oscillator YAG rod.

Marx board (750V)

This board charges 7 capacitors in parallel and then discharges them through fast switching transistors in series so that the voltage on each capacitor is summed. This generates a ~3.6 kV pulse with a rise time of 20 ns. This board is in a metal box next to the Pockels cell.

750 volt power board:

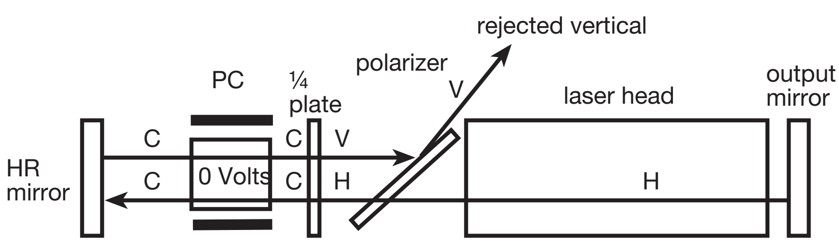
This board, located under the laser bench, generates the dc voltage necessary to power the Marx board. The DC voltage is adjustable by a pot accessible through a hole in the top of the laser bench. Turning the pot clockwise raises the voltage.

Cavity closed:

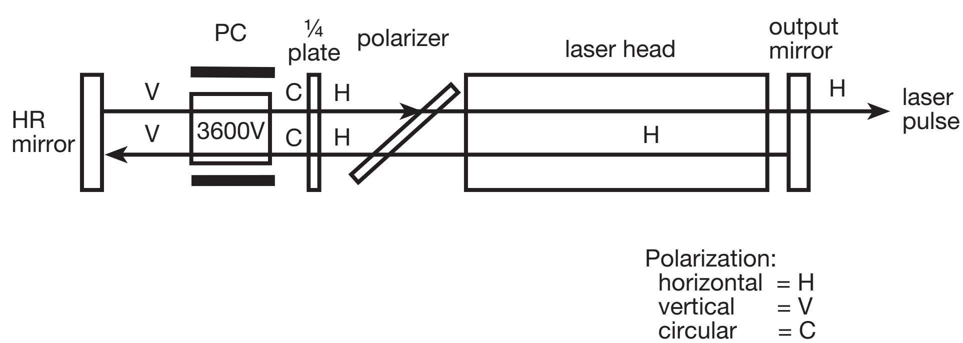
The beam propagating within the oscillator cavity makes a double pass through the Pockels cell and quarter-wave plate. At 0 volts on the Pockels cell (PC) it adds no rotation while the quarter-wave adds 45° with each pass, giving a total rotation of 90°. Thus the horizontal beam that transmitted through the plate polarizer is rotated to vertical and is rejected by the polarizer and no oscillation occurs.

Cavity open:

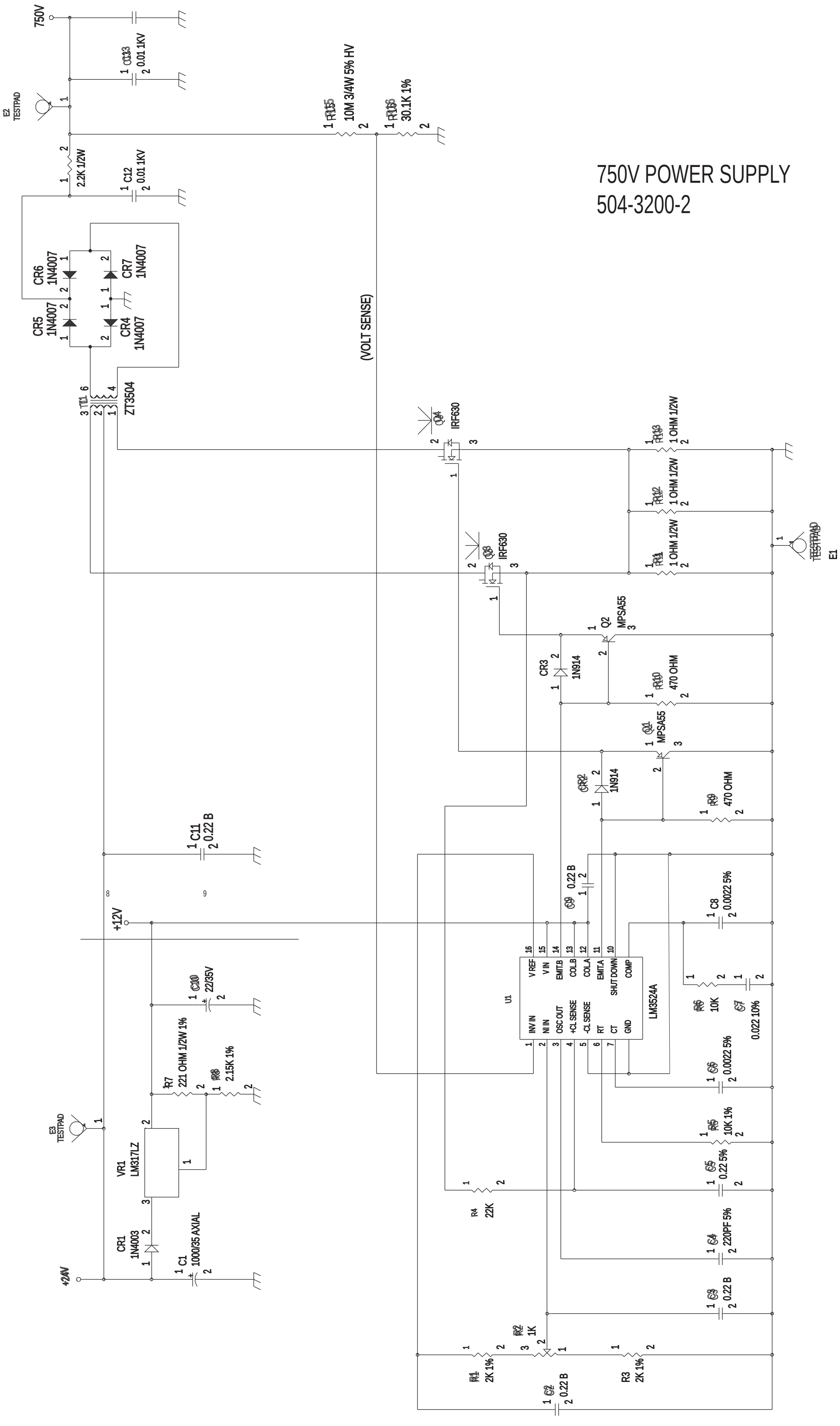
Cavity closed – no lasing.

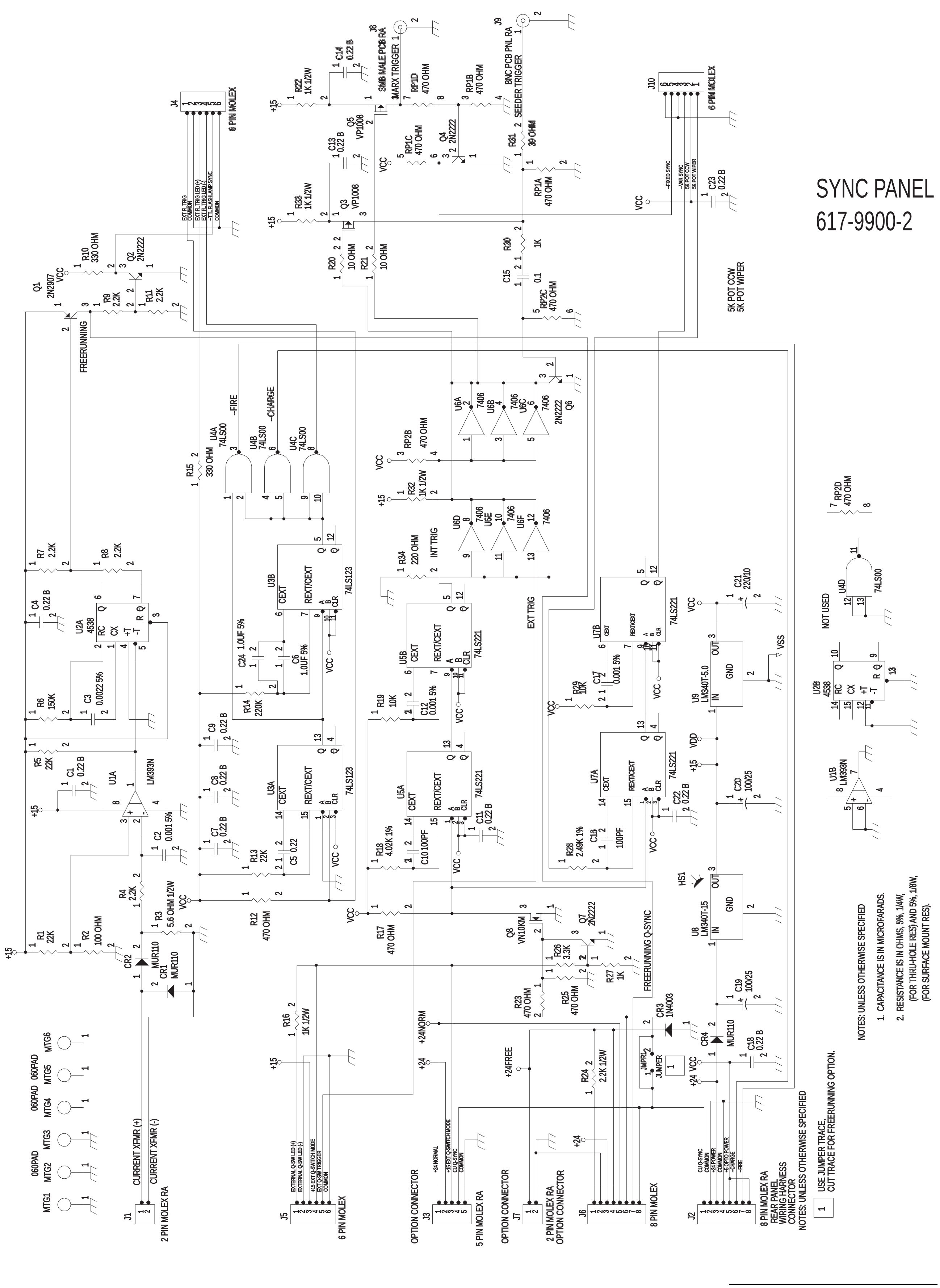


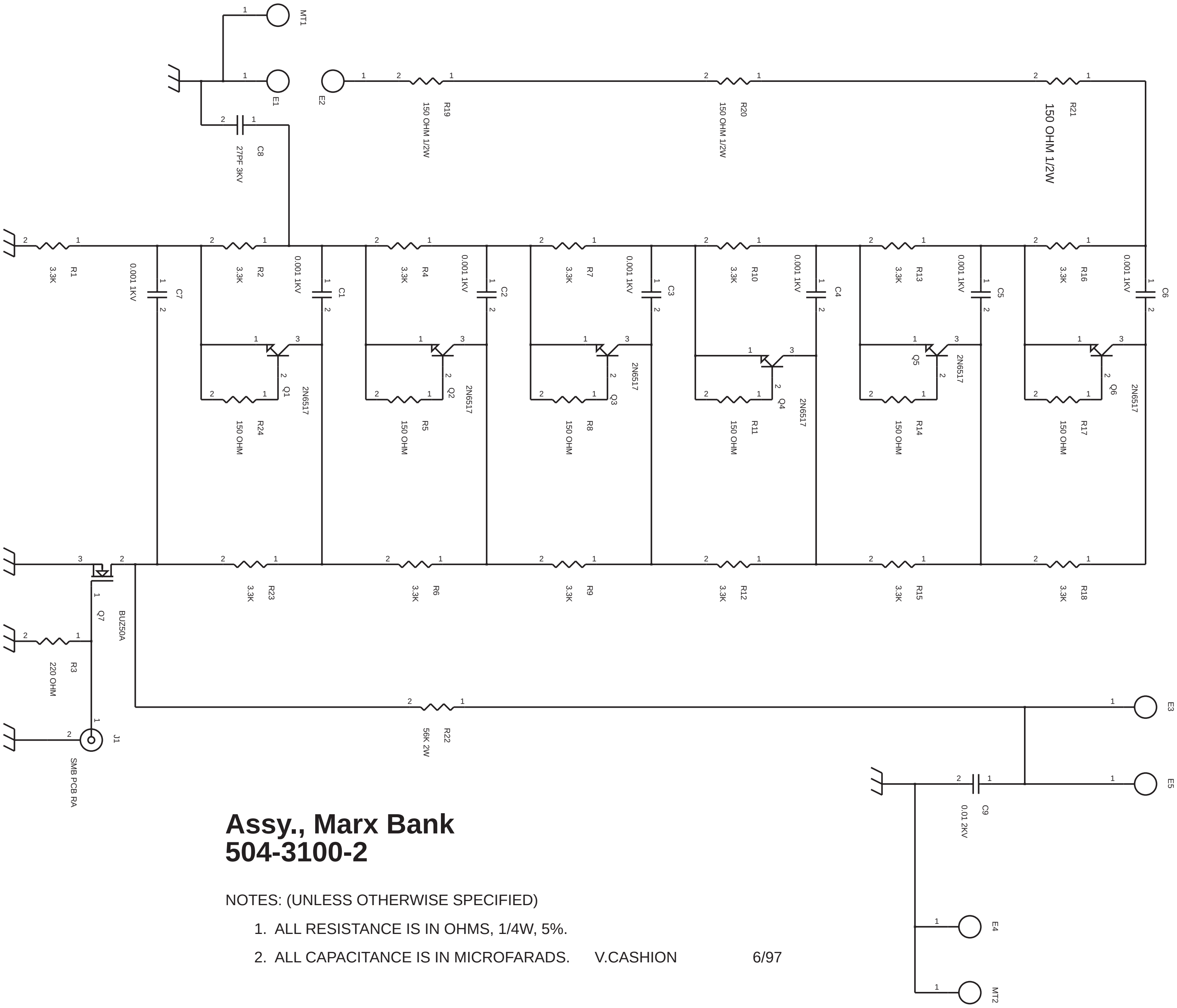
Cavity open and lasing.



The beam propagating within the oscillator cavity makes a double pass through the Pockels cell and quarter-wave plate. At 3600 volts on the PC it adds 45° rotation and the quarter-wave adds 45° with each pass, giving a total rotation of 180°. Thus the horizontal beam that transmitted through the plate polarizer is rotated to vertical **and back to horizontal** so that it is transmitted by the polarizer allowing oscillation to occur.


750V POWER SUPPLY
504-3200-2


SYNC PANEL
617-9900-2
NOTES: UNLESS OTHERWISE SPECIFIED
1. CAPACITANCE IS IN MICROFARADS.
2. RESISTANCE IS IN OHMS, 5%, 1/4W,
(FOR THRU-HOLE RES) AND 5%, 1/8W,
(FOR SURFACE MOUNT RES).
NOTES: UNLESS OTHERWISE SPECIFIED
1 USE JUMPER TRACE,
CUT TRACE FOR FREERUNNING OPTION.

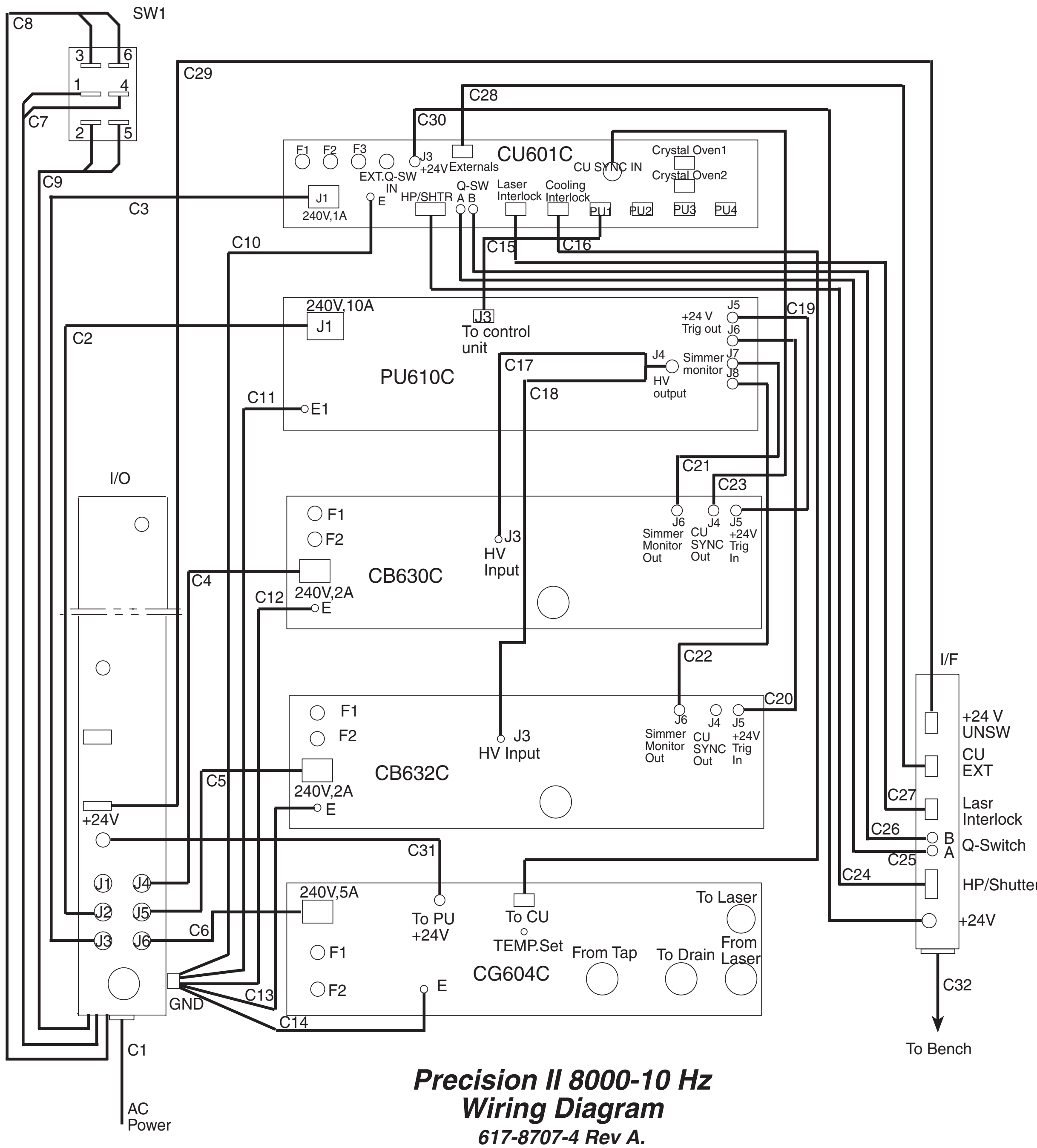


Assy., Marx Bank
504-3100-2

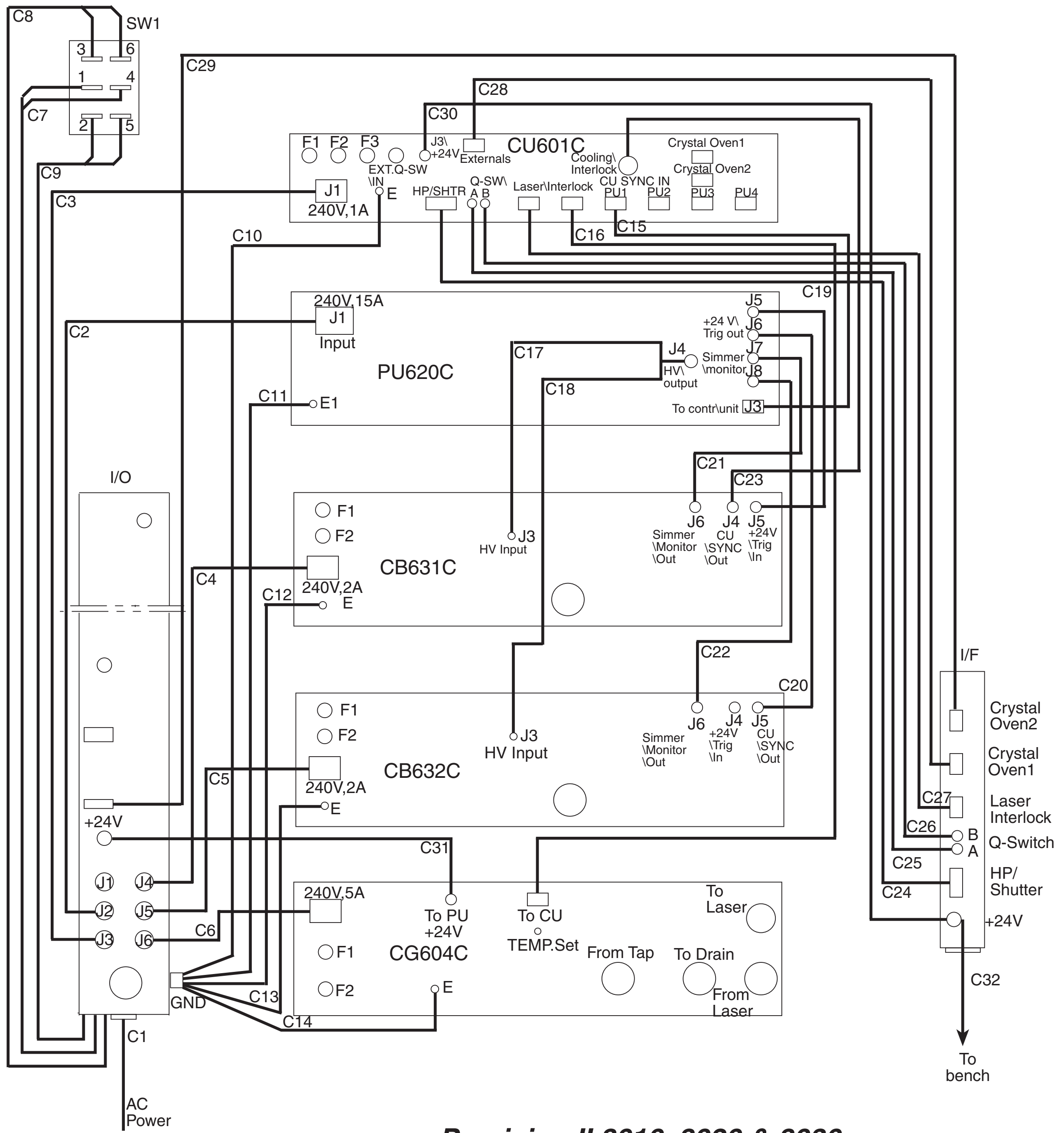
NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTANCE IS IN OHMS, 1/4W, 5%.
2. ALL CAPACITANCE IS IN MICROFARADS.

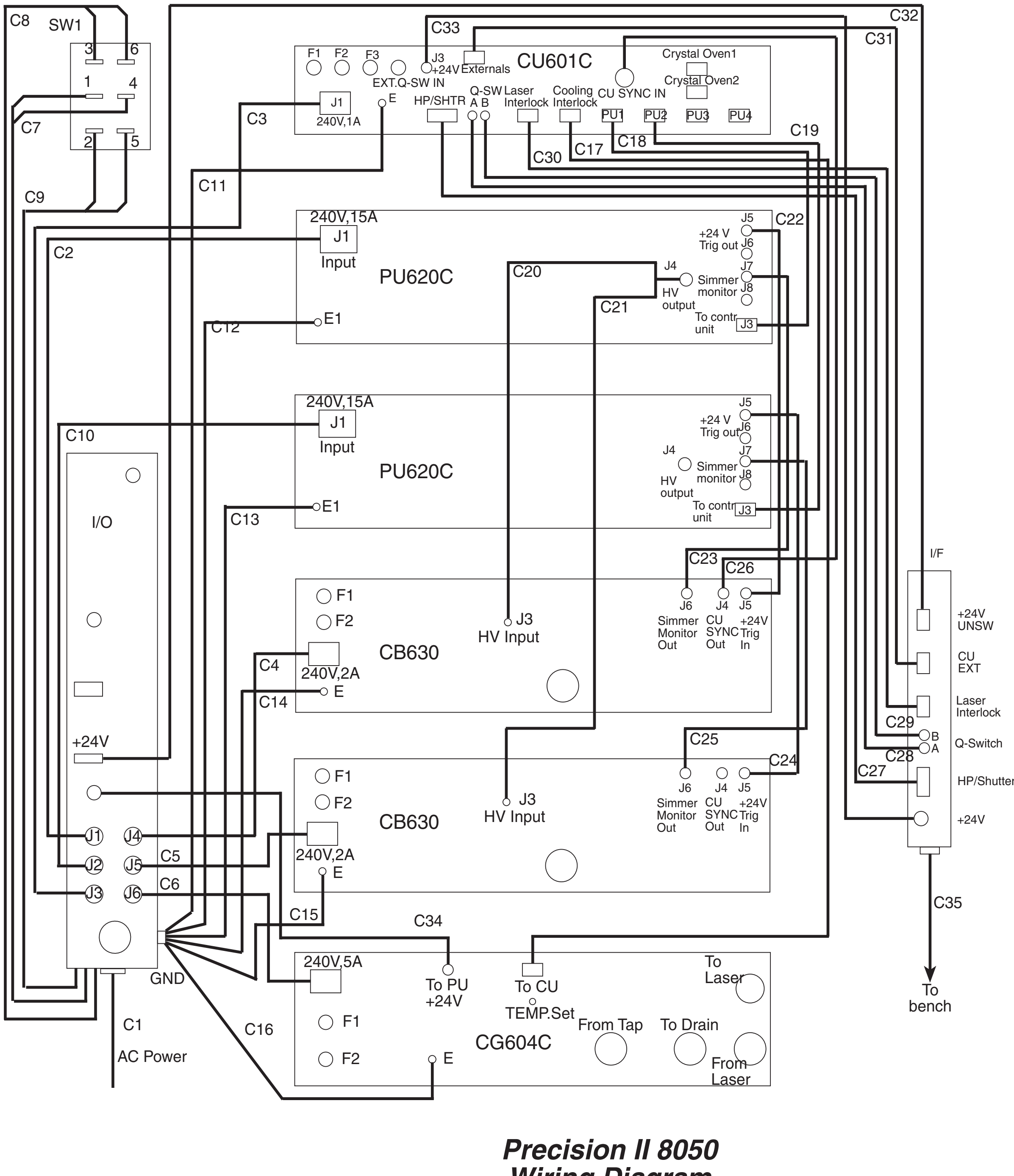
V.CASHION 6/97



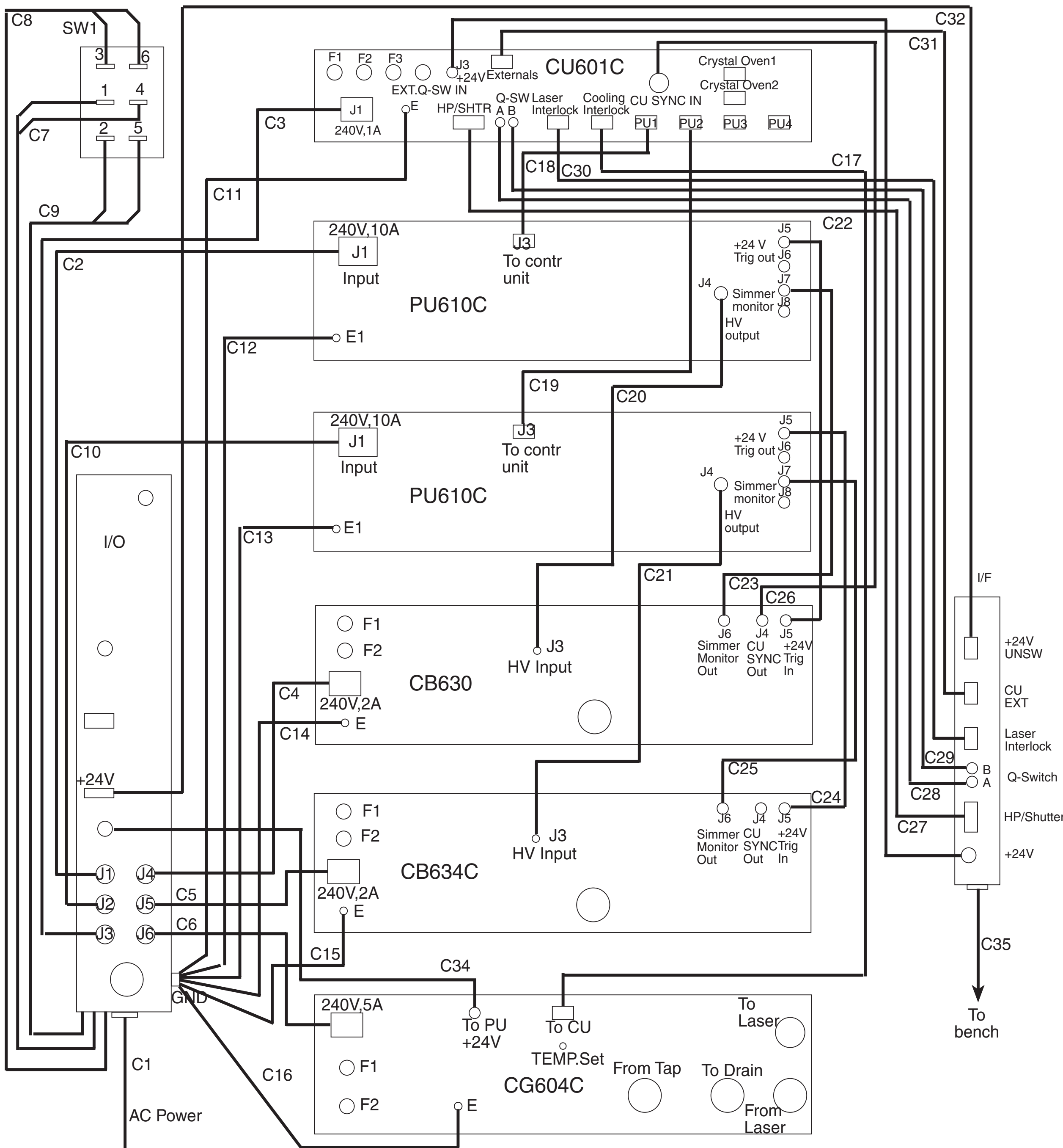
Precision II 8000-10 Hz
Wiring Diagram
617-8707-4 Rev A.



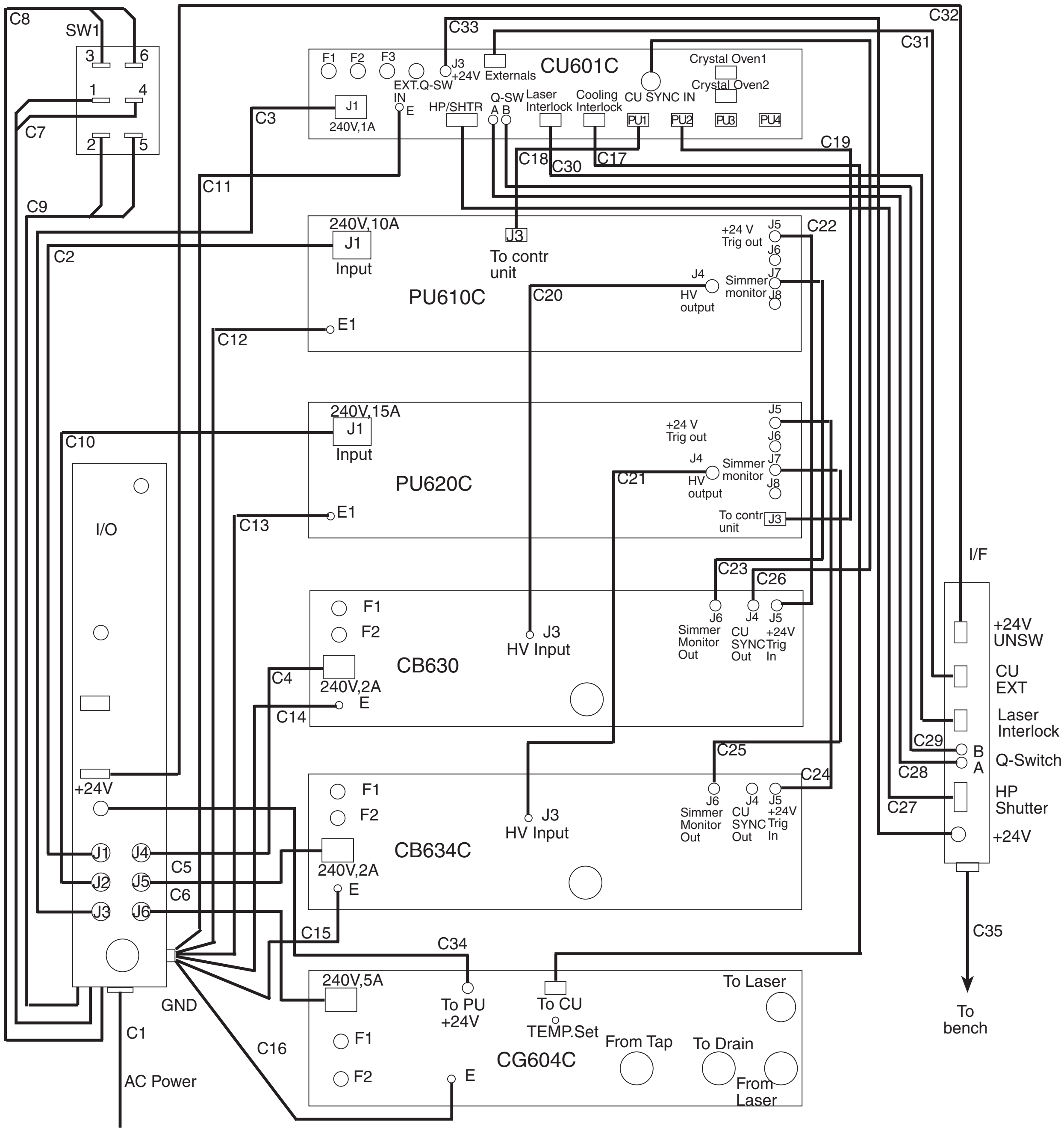
Precision II 8010, 8020 & 8030
Wiring Diagram
617-8708-4 Rev A.



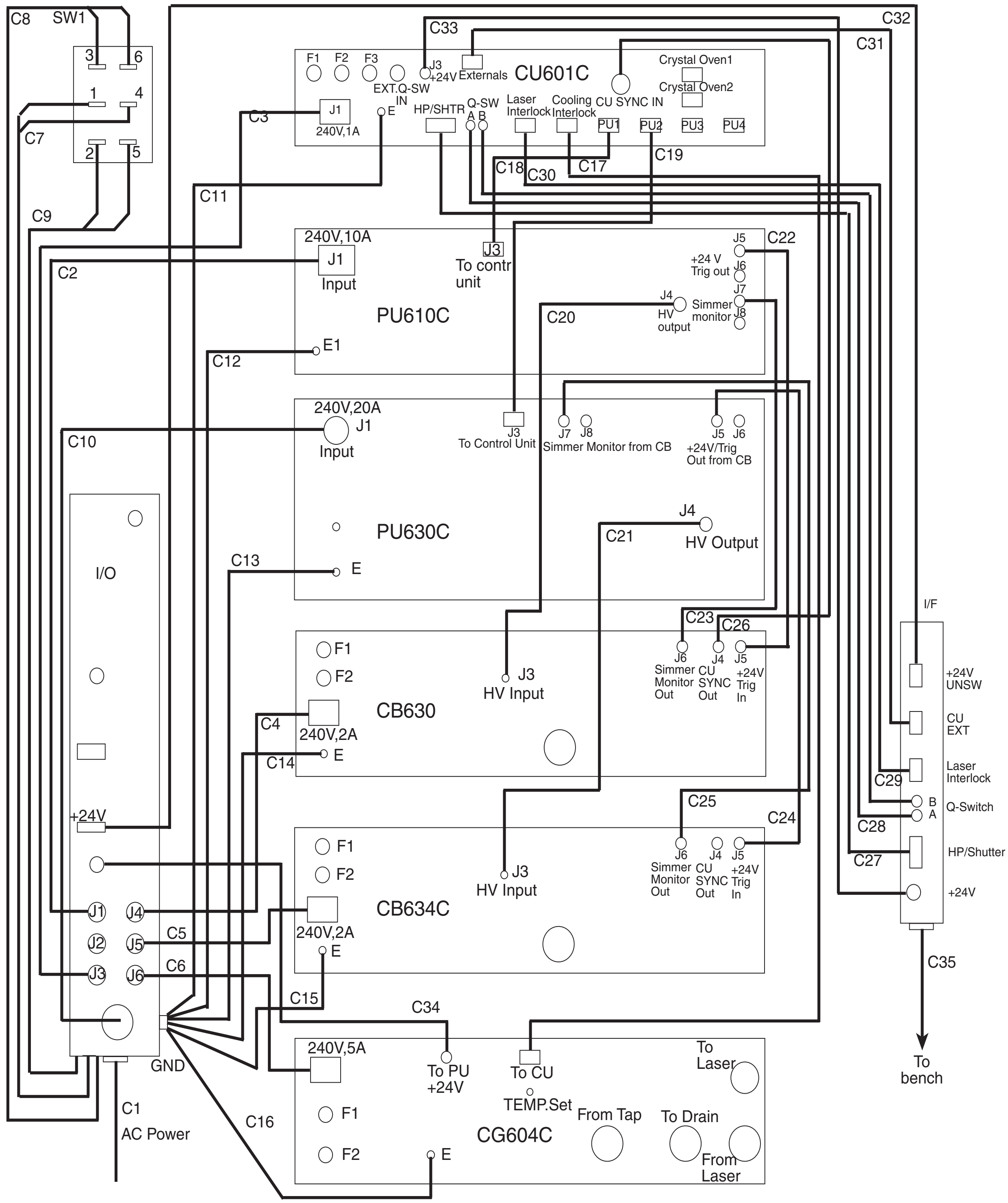
Precision II 8050
Wiring Diagram
617-8711-4 Rev A.



Precision II 9010
Wiring Diagram
617-9910-4 Rev A.

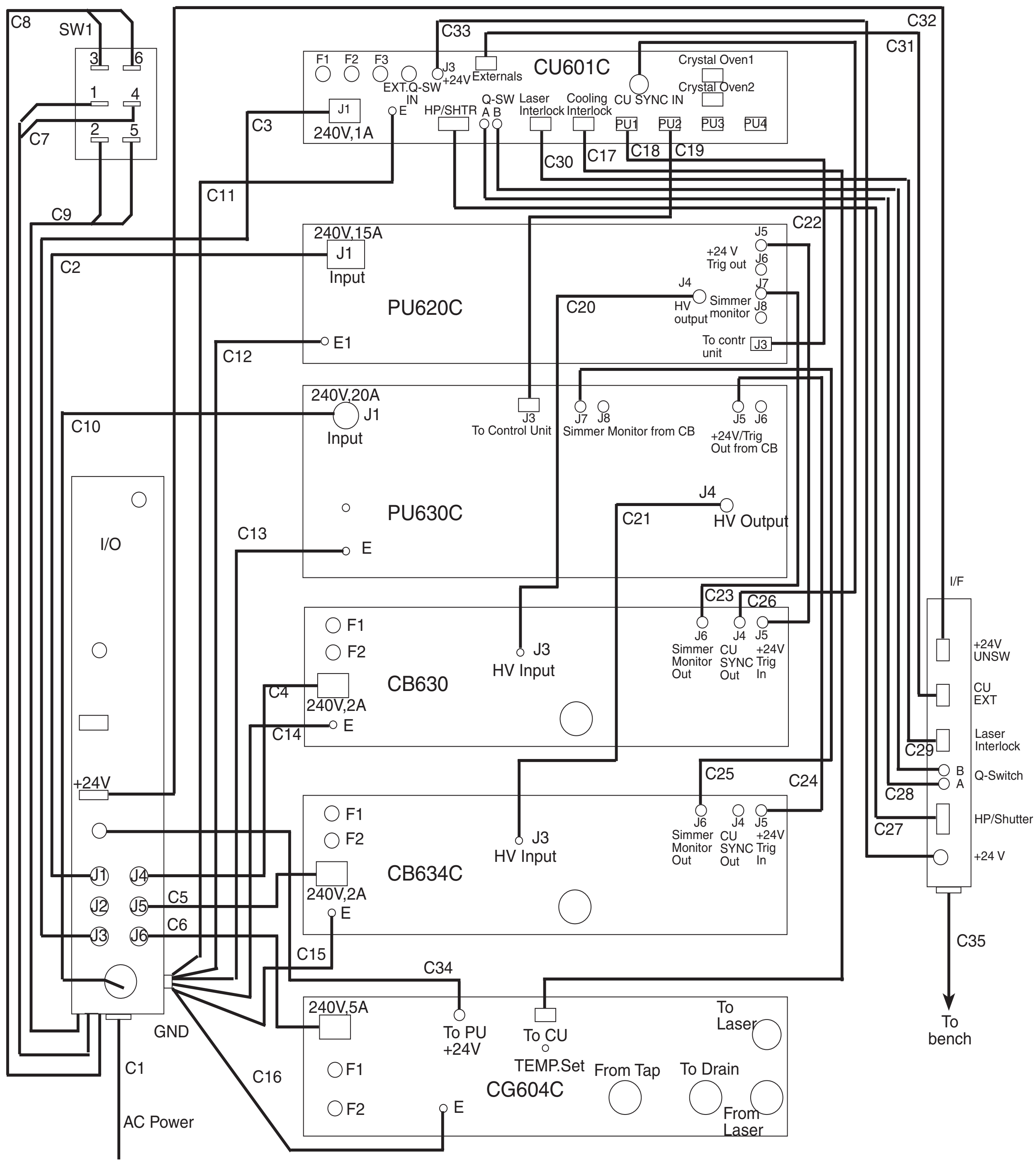


Precision II 9020
Wiring Diagram
617-9920-4 Rev B.



Precision II 9030 Wiring Diagram

617-9930-4 Rev A.

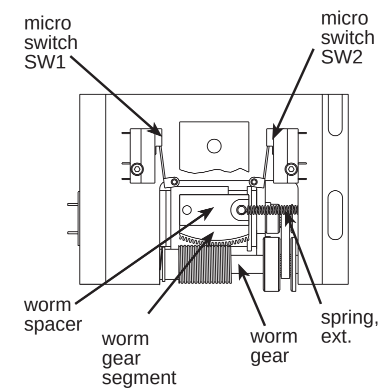


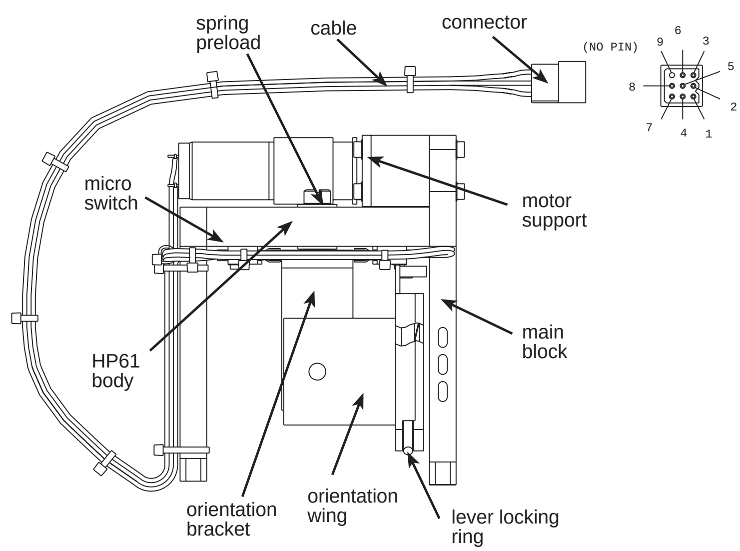
Precision II 9050 Wiring Diagram

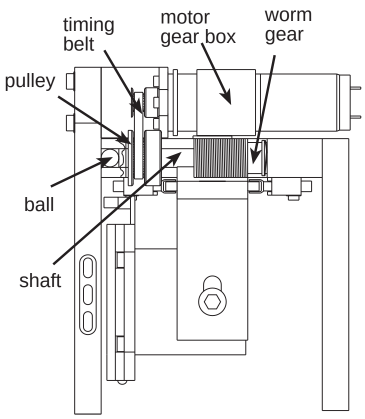
617-9950-4 Rev A.

C. Laser bench mechanics

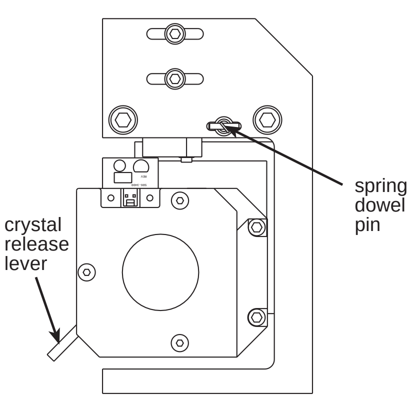
The laser bench mechanics consist of the harmonic positioners (HP70/71). Below is the wiring diagram of an HP70/71 which is used for the second, third and fourth harmonic generators.





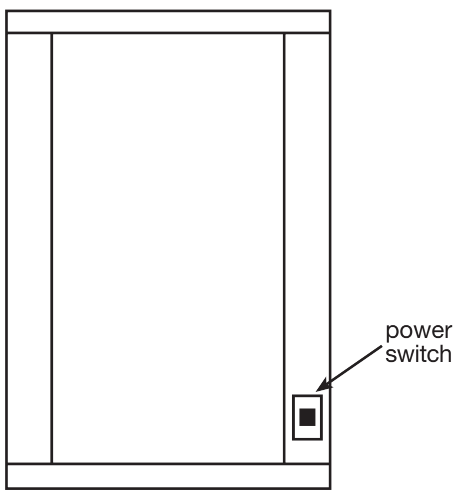


Assy. HP71
608-4220.

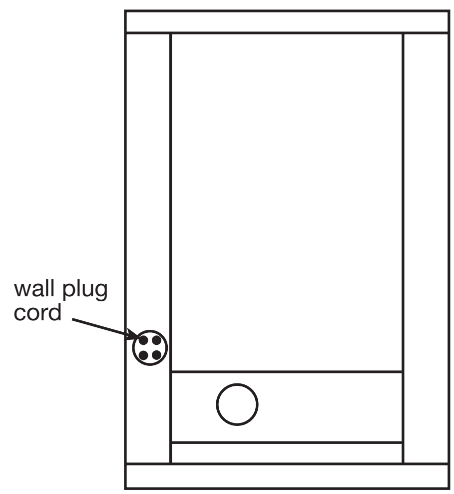


D. Electronics cabinet

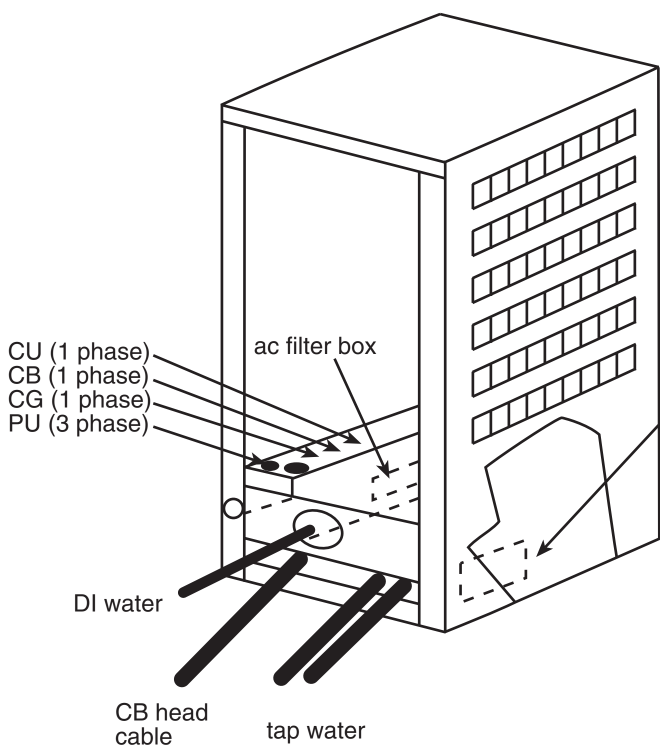
Continuum’s electronics cabinets have a number of PC boards and electrical plugs built into the chassis. Below is a drawing showing the built-in features of the rack. On the next page is a drawing depicting the wiring between the rack mounted modules.



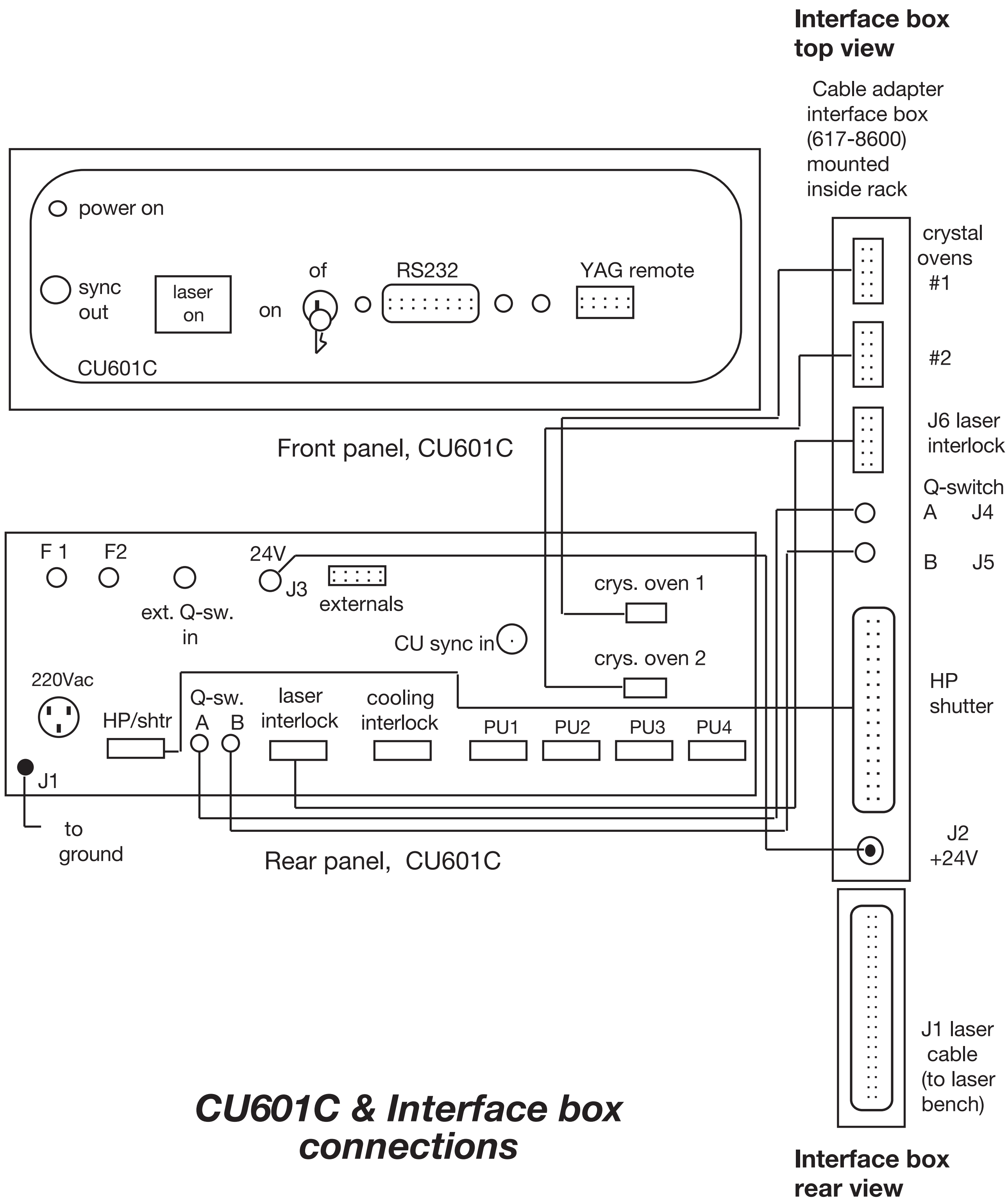
Front view



Rear view



Built-in rack electronics.



CU601C & Interface box connections

Chapter III CU601C Control Unit Contents

Chapter III Subassemblies & Module Descriptions

mini index

E. Control Unit, CU601C

1. General description

The CU601C is a microprocessor based system, which provides hardware interfaces and commands to and from the cabinet components and laser bench. There is also a remote box (RB601) that plugs into the front panel of the CU601C. The remote box allows the user to enter commands on a keyboard and view responses on an alpha-numeric liquid crystal display (LCD). The user may also control the CU601C through an RS232 interface on the front panel.

The interfaces from the rear panel to rack mount are:

- cooling group interlock
- 4 power unit interfaces.

Rear panel to laser bench:

- laser head interlock
- 2 harmonic generators
- shutter
- Q-switch a/b output
- low voltage output (24Vdc).

Other rear panel interfaces:

- ac power input
- auxiliary sync output
- externals
- +24/trig delayed.

Front panel:

- remote box
- RS232
- variable sync output.

The CU601C controls fall into 3 categories -

a) interlock monitoring and crystal heater control

b) external charging and firing control

c) RB601 or RS232 controls which are:

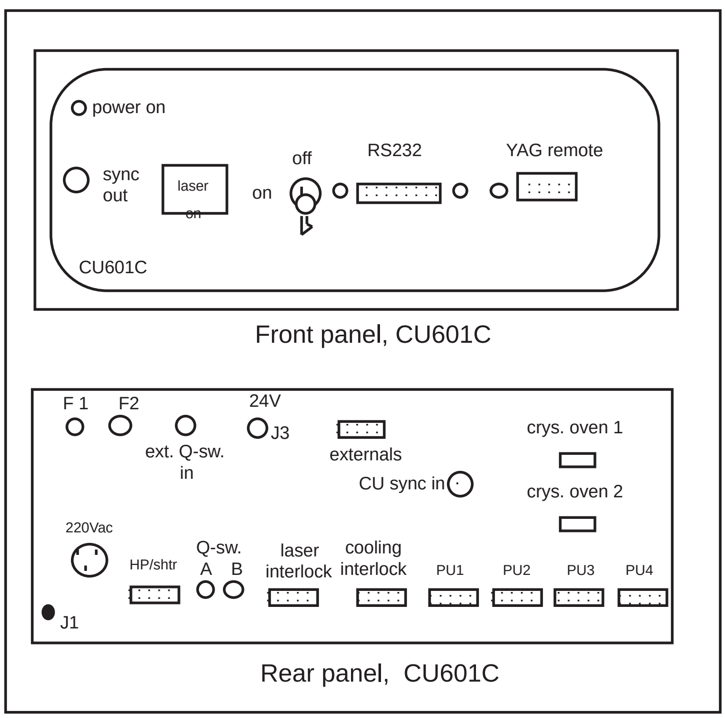
- harmonic generator control
- shutter control
- Q-switch delay
- charging and firing control
- mode selection
- rep rate
- pulse division
- single shot
- storage & retrieval of user programs
- shot counter display.

Rack mount controls

The CU601C provides all of the signals required to control up to four power units. The CU601C initiates charging of the capacitor banks by means of signal exchange with the power units under control. The CU601C also provides cooling group interlocks, which sense water temperature, water level and water flow. A cooling group interlock violation halts the laser operation and reports the interlock violation to the remote box, see drawing on next page.

During a charge sequence, the charge command is sent to the power units to charge the capacitor banks. The CU601C then looks for an EOC (End of Charge) signal from the power units. When all EOC signals are received, the CU601C then is ready to send a fire command. If the CU601C fails to receive an EOC, the CU601C reports an “EOC failure” to the remote box and halts any further fire commands.

CU601C front & rear panels.



Front panel, CU601C

Rear panel, CU601C

Laser bench control

The CU601C provides for all of the signals and/or dc power to control the crystal heaters, harmonic generators, shutter and Q-switch. Harmonic generator limits are reported to the remote box and further movement is prevented in the limit direction. The CU601C controls Q-switch delay timing. The CU601C provides laser bench interlocks, in which the CU601C senses shutter, laser head temp and dye laser (if used) interlock violations. Laser bench interlock violations halt the laser operation and report the violation to the remote box.

2. Structural organization

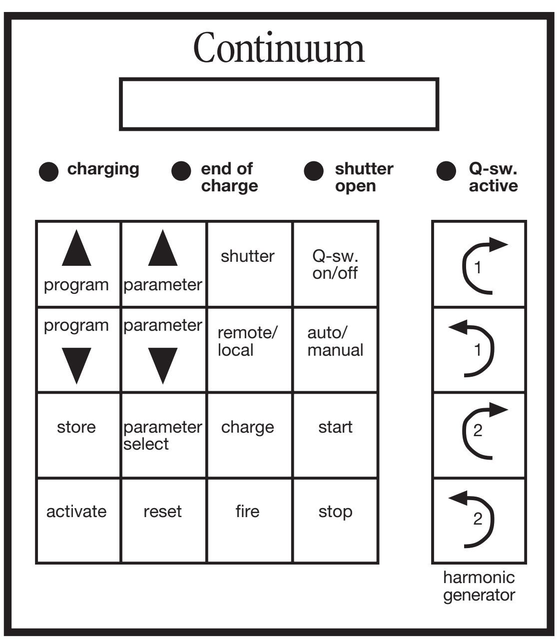
The CU601C has 6 circuit boards and two low voltage open frame linear power supplies. The large circuit board is the microprocessor logic board. The remaining circuit boards are for accessory control, front panel variable sync, crystal oven heaters, power supply and externals.

CU601C front panel indicators, controls and interfaces

a) Power **LED**
When the power on LED is lit, this indicates that the ac line voltage has been applied to the CU601C.

b) **LASER ON** lamp
The Rectangular incandescent lamp has various functions listed below:

RB601 keyboard



Power on delay -
Lamp will flash approximately once per second for six seconds and then remain on. Turning front panel key switch from off to on initiates this sequence. A high pitch beep will occur once during the beginning of this mode. The laser is active and operating after this sequence.

Interlock violation -
Lamp will flash rapidly many times and the pause for about two seconds repeating this over and over until interlock violation is corrected and the key switch is cycled from **OFF** to **ON**. A medium pitch beep will occur once every cycle during this mode. Laser operation is halted during this mode.

Loss of remote box communications -
Lamp will remain on but momentarily turn off approximately once every 9 seconds until communications with

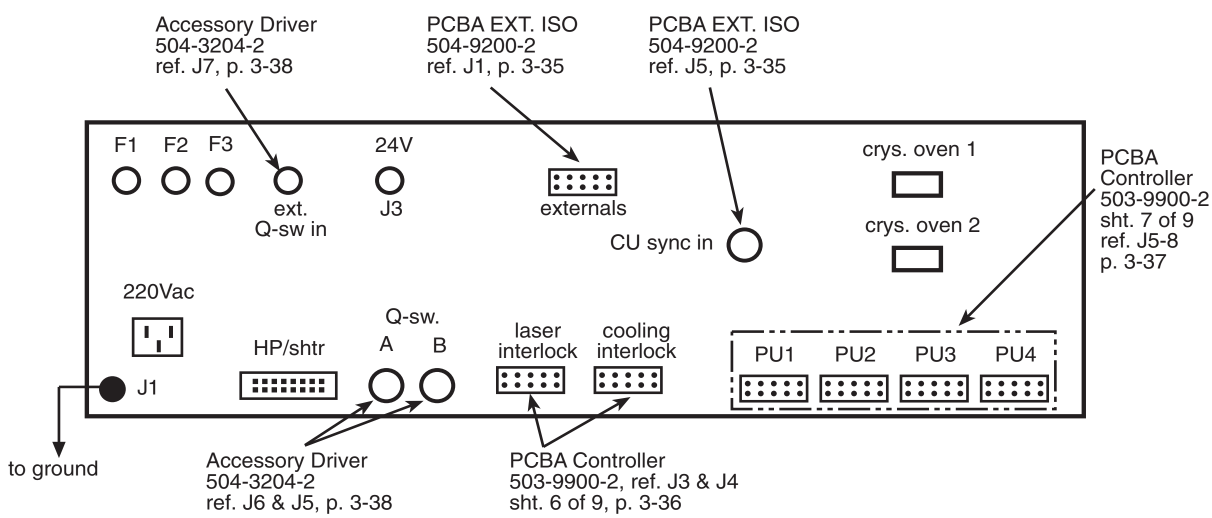
remote box are restored. A low pitch beep will occur once each cycle during this mode. The CU601C will also default to **LOCAL/MANUAL** Mode.

c) **Keyswitch**
The keyswitch, when in the off position, performs a “cold reset”, halts the main microprocessor board and disables the four power unit interfaces on the rear panel. When the keyswitch is turned on, the CU601C initializes, begins its 6 second countdown, defaults to the manual mode with the shutter closed and is ready to accept commands.

d) **Sync out**
The sync out (BNC front panel) provides a 12V 5ns rise time pulse variable in time from 175ns before lasing output to 175ns after lasing. The time adjustment can be made through a small hole to the left of the “SYNC OUT” BNC on the front panel using a small flat blade screw-driver or a pot “tweaker” tool.

e) **YAG remote I/F**
The YAG Remote I/F is a D9 female connector. This connector is for the remote box plug.

f) **RS232**
The RS232 is a D25 female connector and is for RS232 control of the CU601C (see section on RS232, p. 2-13).



PCB references for rear panel connections.

3. CU601C rear panel interfaces

g) F1,F2
F1 and F2 are hi-side and return line fuse holders. The fuses are 1A 250 V Bus Type GDC or equivalent.

h) J1 220 Vac
J1 is the ac line input which provides 220Vac power to the internal linear open frame power supplies.

i) ext. Q-sw.
This BNC connector runs to J7 on the Accessory Driver PCB. By taking the +5 Vdc found on this BNC, "low" will fire the Q-switch.

j) J3 24 V
J3 is a BNC connector which provides 24 Vdc power to the intracavity shutter and the HP70/HP71 on the laser bench.

k) HP/SHTR
This D15 female connector provides control signals to harmonic positioners #1 and #2 on the laser bench. The connector also provides the control signals for the intracavity shutter.

l) Q-switch A/B
Q-switch A output is a SMB type connector which provides the trigger pulse to the Q-switch board on the laser bench and the "seeder trigger". When the Q-switch board receives this pulse the Q-switch opens. This pulse is approximately 7µs long with a 5 ns risetime, and 12 V amplitude. Q-switch B output is identical to Q-switch A and can be used for laser pulse jitter measurement referenced to the rising edge of this pulse, which has a 5 ns risetime.

m) Externals -
This 9 pin "D" style connector runs to J1 on the Ext. Iso PCB. Following the procedure for external triggering listed in the System Operation section will allow external control of your unit.

n) Laser interlock
Laser interlock is a D9 female connector. This connector provides interface to the interlock's signals from the laser shutter, laser head temperature and dye laser (if used).

o) Cooling interlock
Cooling interlock is a D9 female connector. This connector provides interface to the interlock's signals from the

cooling group water flow, water temperature and water level.

p) CU sync in
This BNC connector receives the delayed trigger from the oscillator capacitor bank. The CU601C tracks this signal so that changing the delay on the front of the capacitor bank does not change the Q-switch delay.

q) PU1 - PU4
PU1 through PU4 are D9 female connectors. These connectors provide control signals to and from the power units.

4. Operation

All commands described in this section are referenced to operation of the CU601C through the remote box (RB601). Make sure all connections on the laser system are correctly connected (see wiring diagram, page 3-34), that there are no interlock interrupts, the power has been turned on and the keyswitch is **OFF** with the key removed.

a) Startup of CU601C
The remote box display should now be showing the following message:

```
REMOTE BOX OK
KEYSWITCH OFF
```

Insert key into keyswitch and turn counter clockwise to the “on” position. The remote box will momentarily display the following message:

```
CU601C OK
```

The CU601C will then beep, display a 6 second power on delay countdown, then display the following:

```
MANUAL MODE
SHOT COUNT XXXXXXX
```

The CU601C is now in the MANUAL MODE and the following keys are available for operation:

```
AUTO/MANUAL
CHARGE
FIRE
RESET
HARMONIC GENERATOR #1 CW
HARMONIC GENERATOR #1 CCW
```

HARMONIC GENERATOR #2 CW
HARMONIC GENERATOR #2 CCW
REMOTE/LOCAL

b) AUTO/MANUAL

This key toggles the CU601C between the auto and the manual mode. Initially, the CU601C is in the manual mode and the following is displayed:

When this key is pressed, the CU601C is placed into the auto mode. The

```
MANUAL MODE
SHOT COUNT XXXXXXX
```

display will read:

```
FLASH ONLY PGM1
xxHz  xuS ACTIVE
```

The charge, parameter select, parameter increment, parameter decrement, and remote/local keys are deactivated in this mode and all of the remaining keys are active:

AUTO/MANUAL
START
STOP
FIRE
SHUTTER
RESET
PROGRAM INC
PROGRAM DEC
STORE
ACTIVATE
HARMONIC GENERATOR #1 CW
HARMONIC GENERATOR #1 CCW
HARMONIC GENERATOR #2 CW
HARMONIC GENERATOR #2 CCW

c) CHARGE

When in the manual mode, pressing this key causes a charge command to be issued to the power units. The charge LED lights up during the charging process and will turn off when an “end of charge” signal is received from all power units, resulting with the “end of charge” LED being on. The capacitor banks are now fully charged. If a charge signal is not received from all of the power units, then an “end of charge” failure will occur. The 1st line of the display will show the following:

[x] represents the power unit(s) that have failed to charge. If more than one power unit has failed to charge, the display will sucessively show on the 1st line the power units that have failed.

```
EOC FAILURE PU [x]
```

d) FIRE
In the manual mode, pressing this key causes a fire command to be issued to the power units. The shot count will be incremented by 1.
The power units generate a trigger signal to the capacitor bank(s) and the flashlamp(s) will flash. If the fire key is pressed, without the capacitor banks charged, the CU601C halts the issuance of a fire command to the power units. The fire button may also be used as a “single shot” command when in the automode (refer to “PARAMETER SELECT” below).

e) SHUTTER
The shutter only opens in auto mode in program 2 or greater. Pressing the shutter key causes the shutter to toggle open or closed. The shutter LED, when on, indicates that the shutter is open and the oscillator cavity is free to oscillate. When the shutter LED is off this indicates that the shutter is inserted into the oscillator cavity and lasing action is inhibited.

f) Q-SWITCH ON/OFF
This key must be **ON** in order to activate the Q-switch. When the Q-switch is **ON** the red LED labeled “Q-SWITCH ACTIVE” will also be lit.

g) PARAMETER SELECT
This key only works in the auto mode and when a program has been selected, but not activated. This mode will not change PGM 1-3 which are factory set. When pressed a blinking cursor will appear over one of the three laser parameters (Pulse division, Rep rate, or parameter). When the cursor is positioned over the appropriate parameter, that parameter may be changed using the parameter increment or parameter decrement keys.

The Q-switch delay shows the delay time that the CU601C will wait before Q-switch action occurs (after receiving a Q-switch trigger signal from the capacitor bank). The rep rate parameter is the pulses per second between flashlamp firings. Pulse division is the parameter that determines at what fraction of the rep rate the Q-switch operates. For example:

pulse division F/3 means that the Q-switch will operate every third flash lamp flash. The net result is that the laser is firing at $^1/_3$ the repetition rate of the flash lamp. If the pulse division is decremented below F/1, **SINGLE SHOT** will be displayed on the 1st line and Q-switching action will be inhibited. If the fire button is pressed, while the **SINGLE SHOT** is displayed, Q-switch action will occur once on the next fire command issued by the CU601C (starting in the automode) and the laser will fire. The following example is what the display will show (when in single shot is selected):

h) PARAMETER UP/PARAMETER DOWN
These keys will increase or decrease the selected param-

```
SINGLE SHOT PGM4
10Hz 200uS SELECT
```

eter to their limits. Holding either parameter inc or parameter dec key down causes the key to repeat. All parameters retain their values after power down.

i) RESET
This key puts the CU601C into the manual mode, shutter closed, Q-switch off and ready to accept commands. This key is a "warm reset" and may be used if the front panel keyswitch, is out of reach of the operator. The display will read:

j) START

```
MANUAL MODE
RESET
```

Used to start the automode. This key will begin the automatic charging and firing of the laser. The laser will run at the present active values of the rep rate, Q-switch and pulse division. Q-switch action will be held off for 8 seconds after start is pressed. If an end of charge signal is not detected from any of the power units then the auto mode is halted and the display will read:

```
EOC FAILURE
10Hz 1uS ACTIVE
```

To determine which power unit is not charging, see manual mode, c) **CHARGE**.

k) STOP
Used to stop the auto mode. This key will immediately halt the auto mode after the last fire command has been issued, leaving the capacitor banks in a discharged state.

The shutter will be closed and the Q-switch will be turned off when this key is pressed.

l) PROGRAM UP/PROGRAM DOWN
When in auto mode, these keys select 1 of 16 user programs stored in memory by incrementing or decrementing the program number. After pressing either of these keys, the display will be put into the "select mode". Next is an example of this mode:

```
F/1          PGM4
10Hz 200uS SELECT
```

The "select mode" will be displayed as long as parameter increment, parameter decrement, or parameter select keys are pressed at least every 15 seconds else the "select mode" will time out and the display will return to the "active mode".

m) STORE
When in automode, and the display is in the "select mode", this key will store current selected program. To properly store a program, first select the desired program number, edit the parameters (if necessary) then press the store key. Any old program will be erased and the new values will be stored. The stored programs will be retained after power down.

n) ACTIVATE
When in automode, and the display is in the "select mode", this key will allow you to activate any selected program. To properly activate a program, first select the desired program number, then press the activate key. The selected program will become the active operating parameters of the laser. The following is an example of the active display:

```
F/1          PGM4
10Hz 200uS SELECT
```

o) Harmonic Generator #1 CW,#1 CCW,#2 CW,#2 CCW
The harmonic generator controls consist of two pairs of keys. These key pairs control the clockwise and counter clockwise rotation of two harmonic generator positioners on the laser bench. For example: Pressing the harmonic generator #1 CW key will cause the harmonic generator positioner #1 to rotate clockwise. If you continue to hold down the key, the positioner will continue to rotate in that direction. If a limit is reached, the remote box will beep. The harmonic generator positioner will no longer move in the direction of the limit.

p) REMOTE/LOCAL

This key is used to place the CU601C into the remote mode or local mode of operation. Local mode so far has been discussed. Remote mode places the CU601C into a mode in which the CU601C may be controlled through the front panel RS232 connector. When in the remote mode, the only key available for operation is **REMOTE/LOCAL**.

To go into the remote mode, first press the manual key and then press the remote/local key and the display will read:

```
REMOTE
REMOTE MODE
BAUD=[XXXX],N,8,1
```

[xxxx] represents the selected RS232 baud rate. The RS232 channel specifications are: no parity, 8 data bits, and no parity. These parameters are fixed.

If no host computer is interfaced to the RS232 connector, the CU601C will "time out" after 5 seconds, beep and do a "warm reset". The CU601C will repeat this cycle until some communications (either the remote box or the host RS232 computer) are restored. If the remote/local key is pressed again, this will restore communications and the CU601C may be controlled again. The CU601C must always be in communications with some controller or it will "time out". This "keep alive" feature is necessary to always guarantee that the laser system is under some control. For more information on remote RS232 control see Chapter II, System Operation.

5. Troubleshooting the CU601C

Security interrupts

Interlock signals come from two D9 connectors on the rear panel of the CU601C. These connectors have cables that go to the laser bench and the cooling group. If an interlock signal is sensed by the CU601C, any present operation of the laser is immediately halted and the security interrupt(s) is(are) reported to the remote box. To resume laser operation, the interlock problem(s) must be corrected and the **CU601C reset by the front panel keyswitch.** The interlock interrupt(s) is(are) reported to the remote box along with LED's flashing. The CU601C front panel lamp will flash rapidly and then pause along with a beep. The interlock cycle will repeat until corrected. If more than one violation occurs, then the interlock interrupts are sequentially reported on the 1st line of the display. For example: A shutter interlock violation would read like the following (on the remote box display):

```
SHUTTER   INTLK
RESET KEYSWITCH
```

The following is a list of interlock interruptions sensed by the CU601C:

From Laser Bench	**From Cooling Group**
Shutter	Water flow
Dye	Water temp.
Laser Head	Water level

Traps
Traps are internally generated microprocessor interrupts. A trap indicates that something has gone wrong with the operation of the CU601C. The traps that can occur are listed as follows:

- Illegal instruction
- Bus error
- Address error
- Spurious interrupt.

If you see any of these traps being reported to the remote box, try resetting the CU601C by turning the front panel keyswitch **OFF** then **ON**.

Usually this corrects the problem. If it does not, contact Continuum for service.

6. Maintenance

New Battery
The CU601C uses a battery to backup the CMOS memory on the microprocessor board. This battery is a type "C" size 3.6V lithium and should have a lifespan of five years. Care should be taken when handling lithium batteries. Read warnings on battery case. The battery is located in the CU601C chassis and is easily removed from its holder. If replacement is necessary, replace with same type or equivalent. Make sure of proper polarity when inserting into the battery holder. Alkaline batteries may not be used because they only supply 1.5 volts. The CU601C will detect a battery voltage failure or if a new battery has been installed. If this occurs the remote box will go through the six second countdown, beep six times and display:

```
NEW BATTERY
SHOT COUNT 0
```

The CU601C will beep two long beeps during a start up when the battery has failed or been replaced. After a battery failure or a new battery has been installed, the CU601C will default the active parameters to the following values:

```
REP RATE         10Hz
Q-SWITCH DELAY    1uS
PULSE DIVISION    F/1
SHOT COUNT          0
```

All 16 user programs will default to the following values:

```
REP RATE       10Hz
Q-SWITCH DELAY 1uS
PULSE DIVISION F/1
```

The rep rate max. and rep rate min. limits will default to the following values:

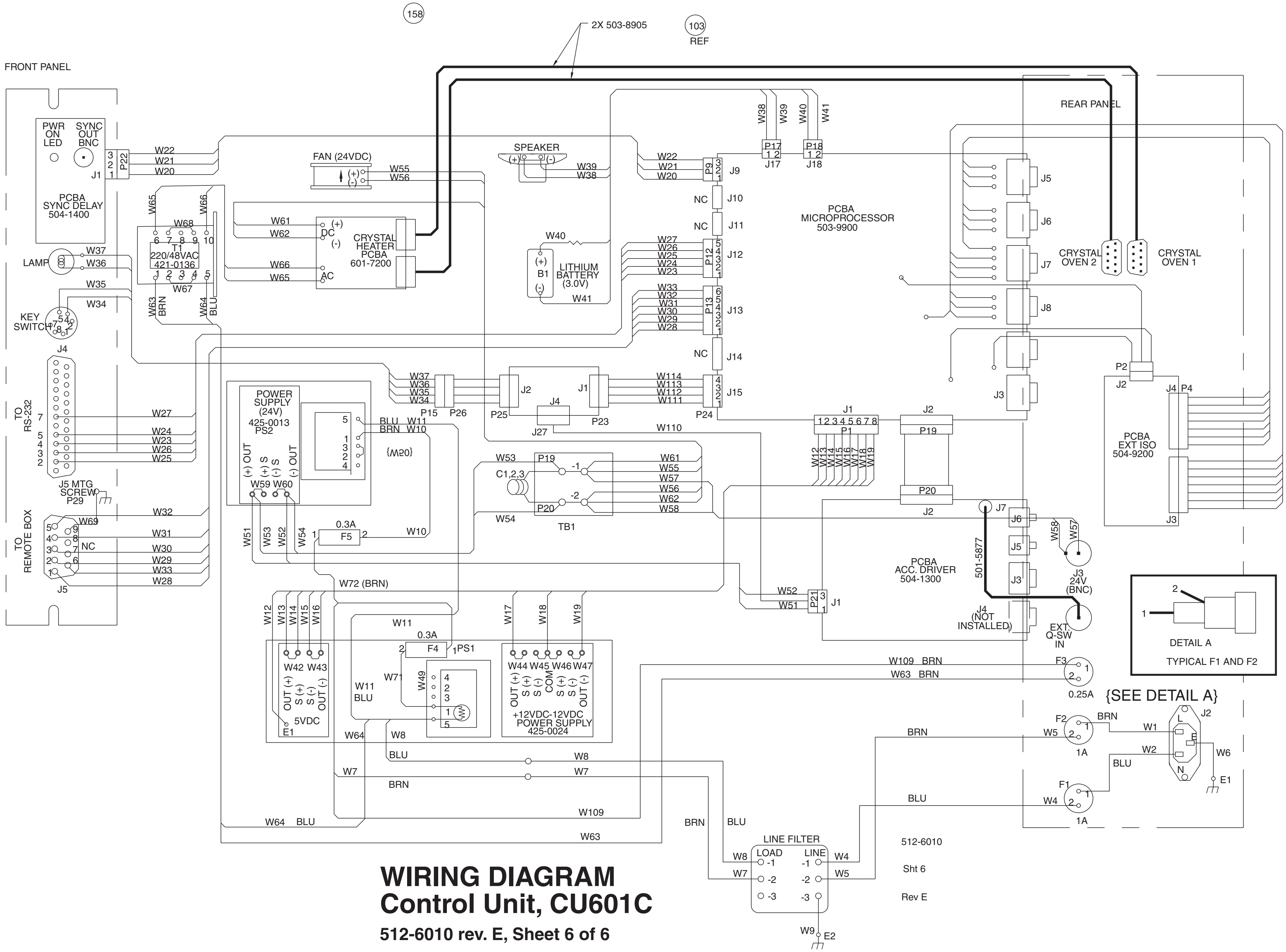
```
REP RATE MIN 1Hz
REP RATE MAX 15Hz
```

The rep rate max. and rep rate min. values will have to be reset. Call Continuum for help. The RS232 baud rate will default to:

```
BAUD RATE   9600
```

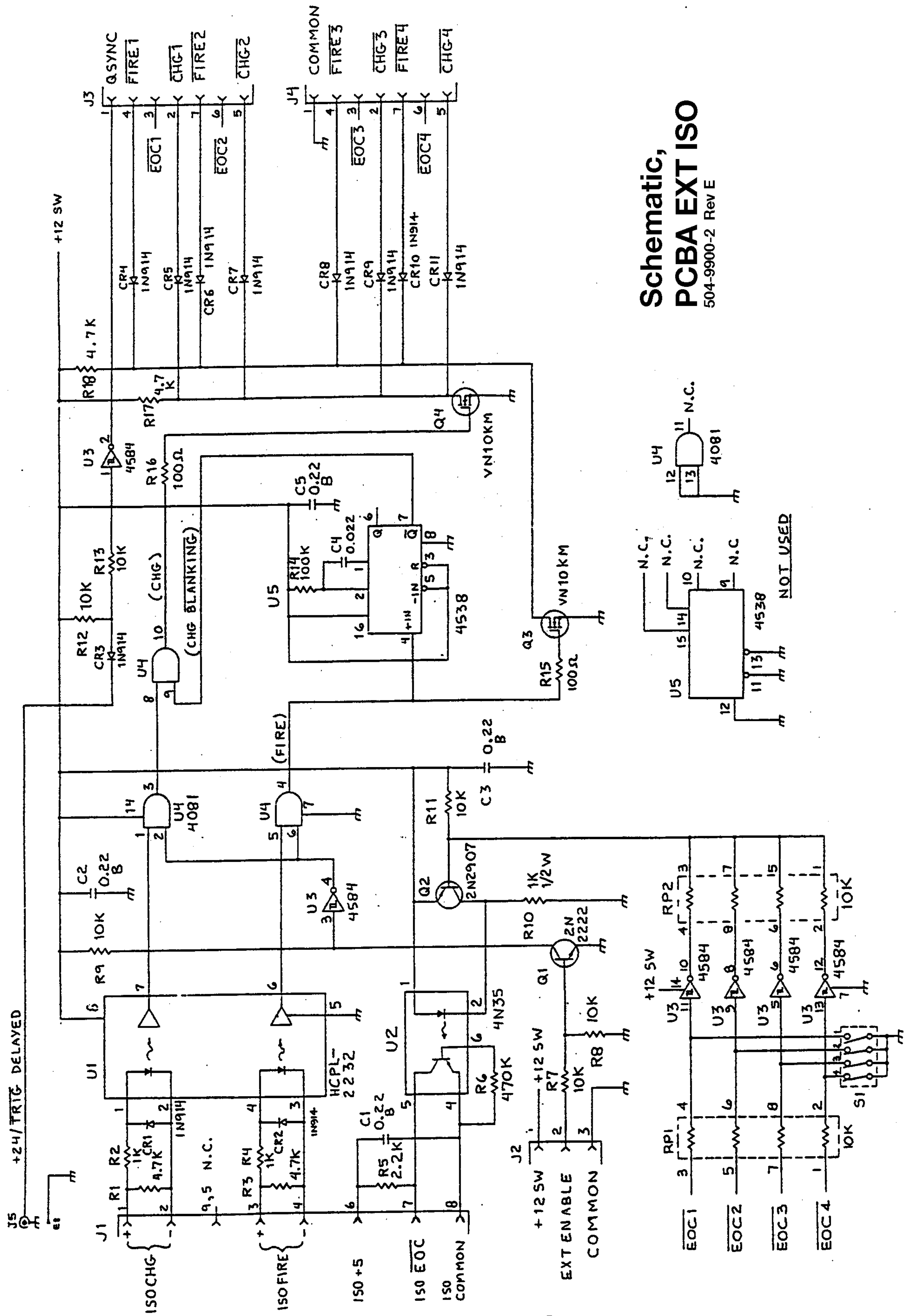
The host RS232 baud rate may have to be set to a new value if the host computer program is different from the default baud rate.

The last PU will default to 1.

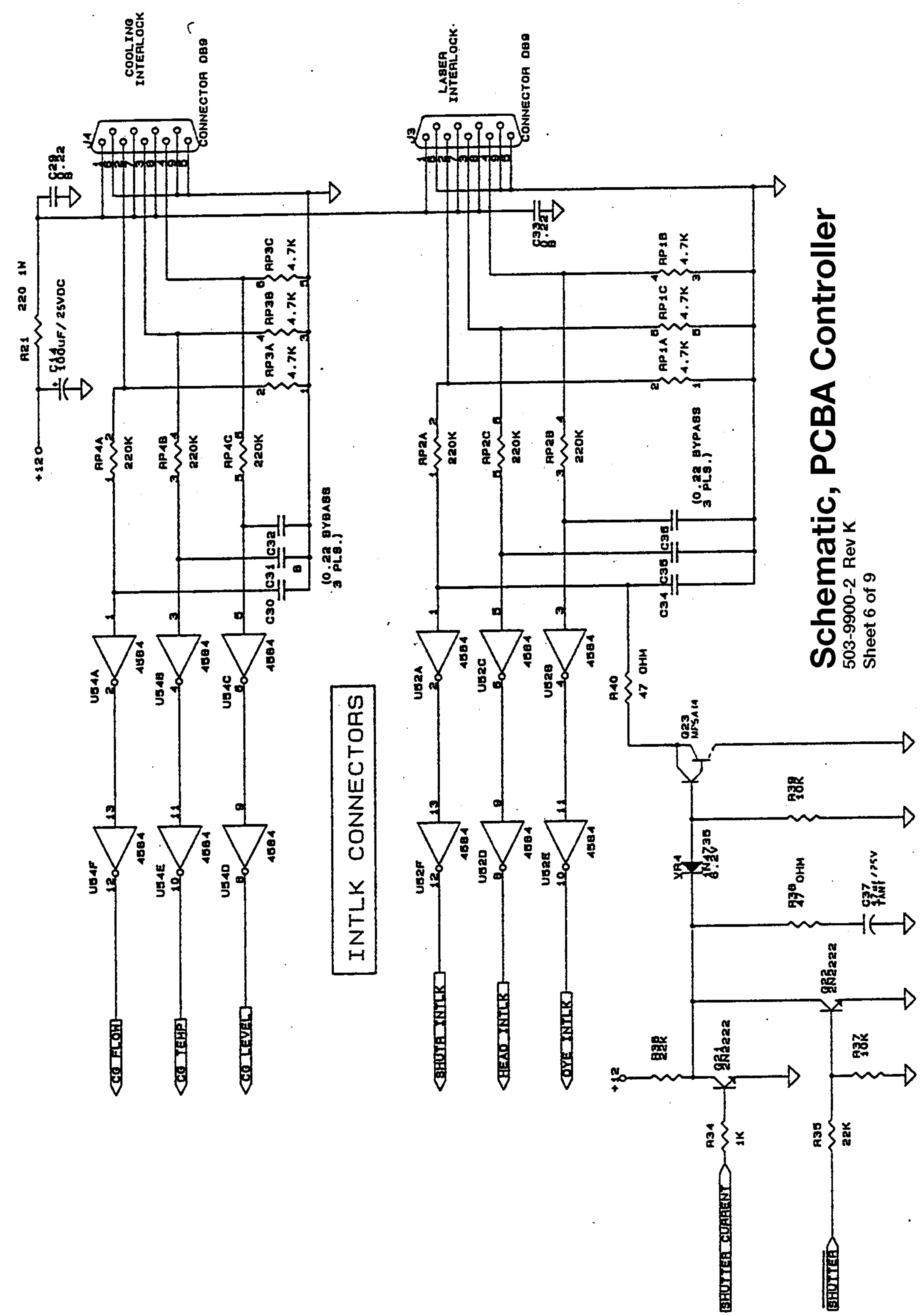


WIRING DIAGRAM
Control Unit, CU601C

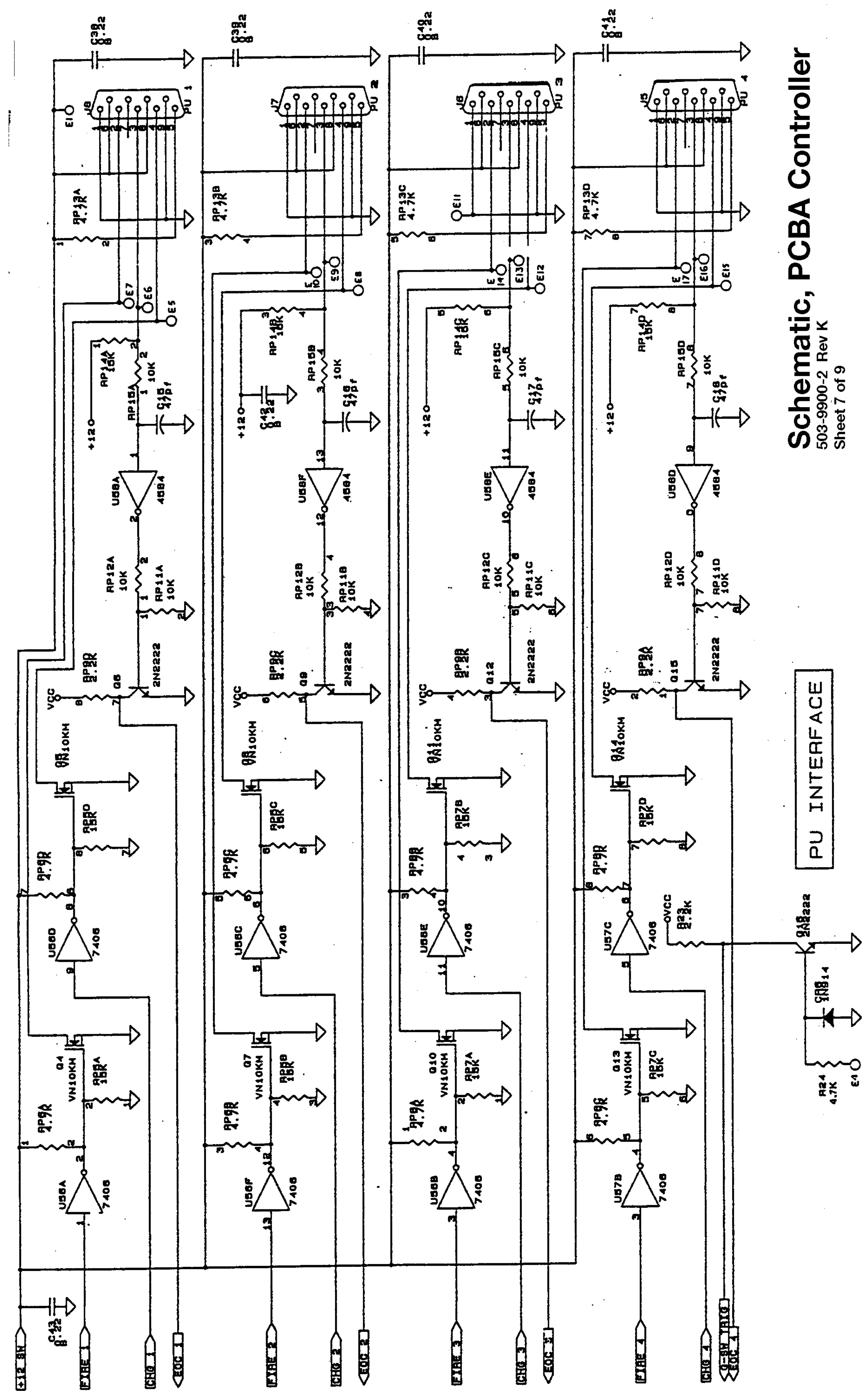
512-6010 rev. E, Sheet 6 of 6

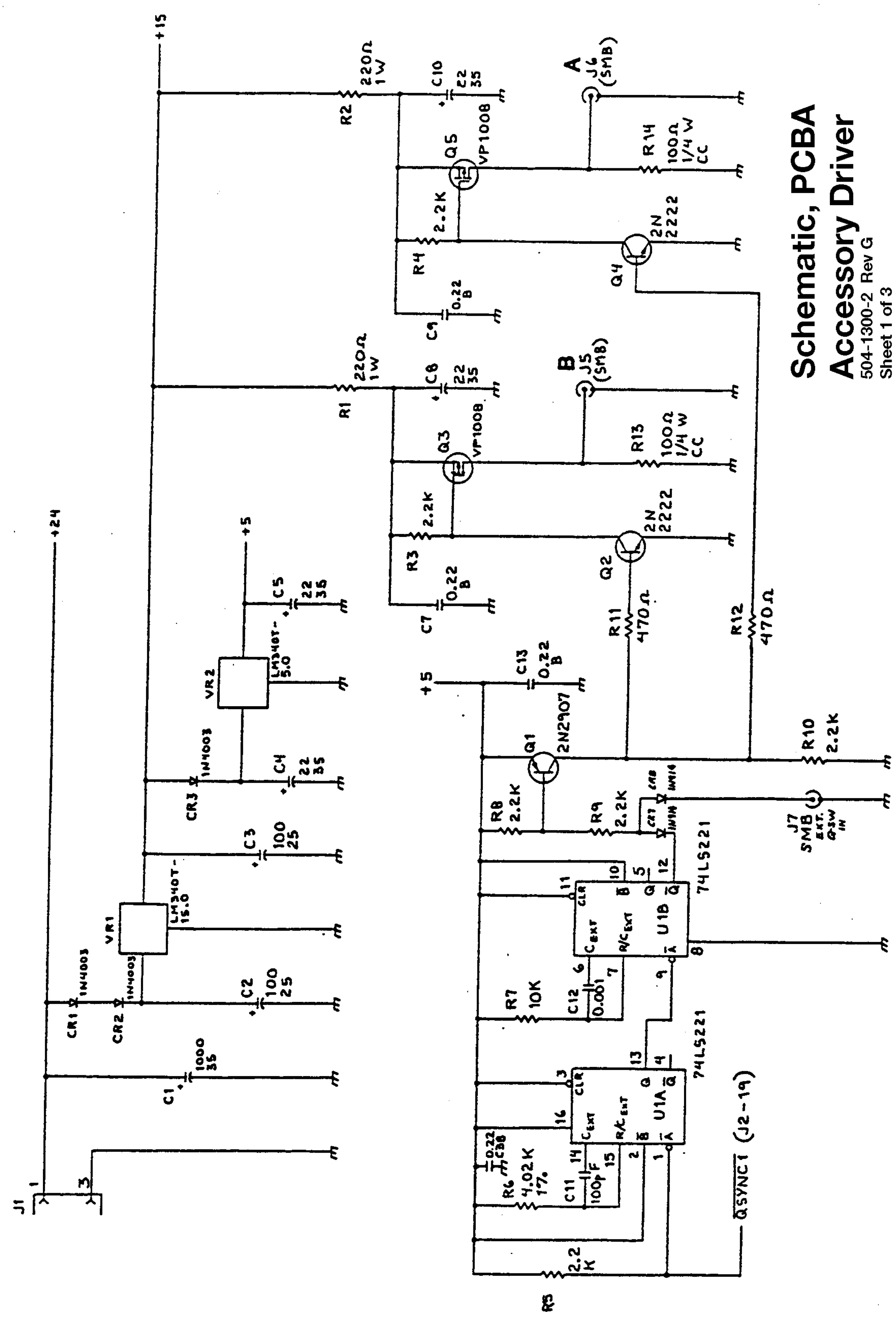


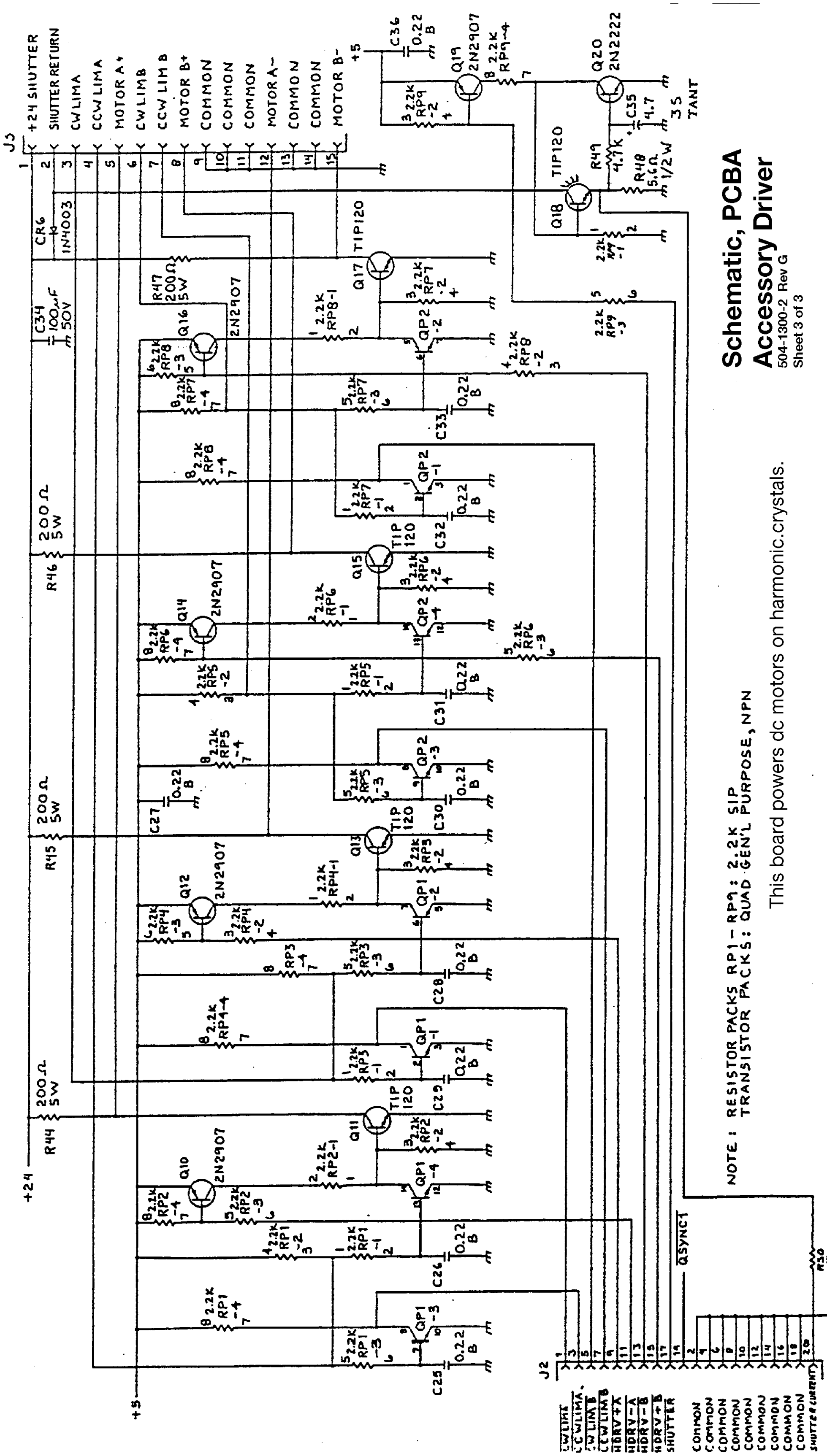
Schematic, PCBA EXT ISO
504-9900-2 Rev E



Schematic, PCBA Controller
503-9900-2 Rev K
Sheet 6 of 9

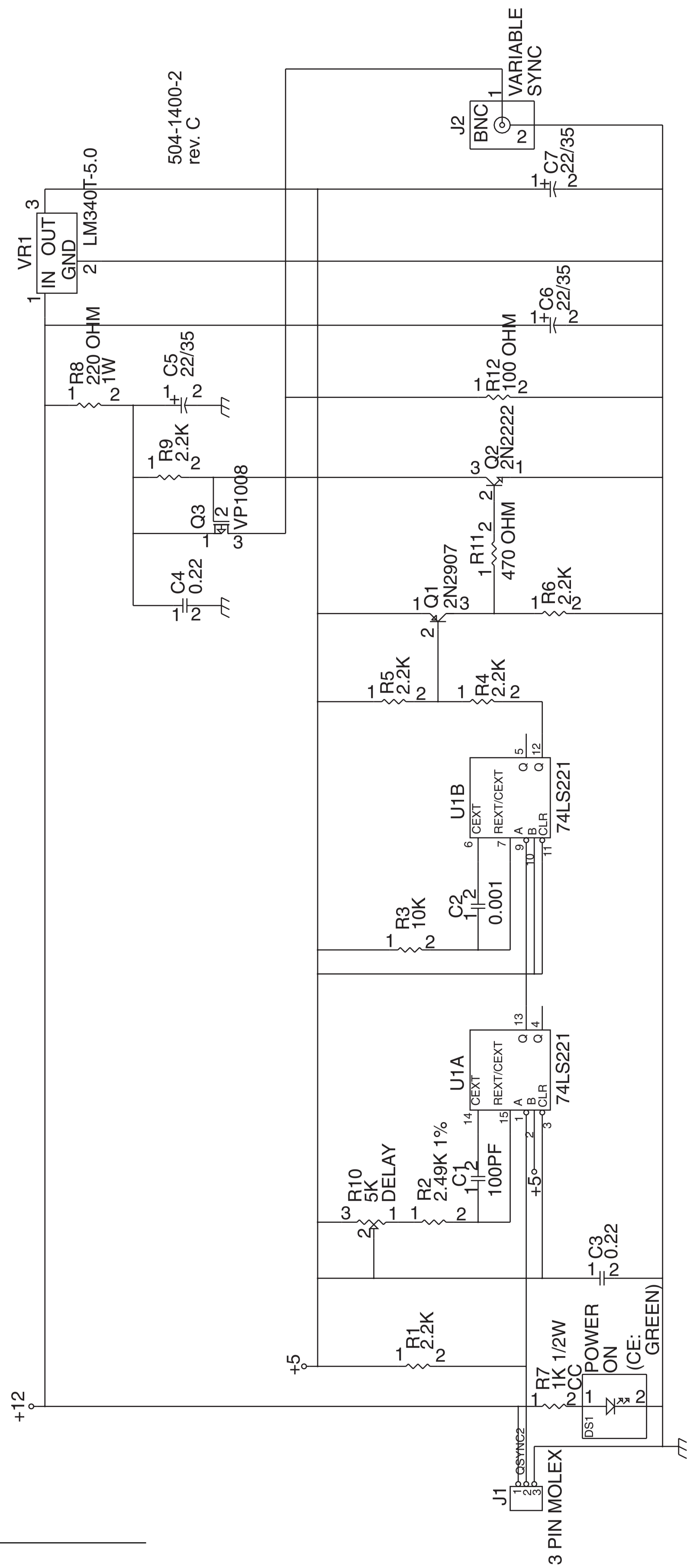

Schematic, PCBA Controller
503-9900-2 Rev K
Sheet 7 of 9
PU INTERFACE


Schematic, PCBA
Accessory Driver
504-1300-2 Rev G
Sheet 1 of 3



Schematic, PCBA Accessory Driver
504-1300-2 Rev G
Sheet 3 of 3

This board powers dc motors on harmonic.crystals.



Sync delay PCB
504-1400-2, rev. C.

Chapter III PU600C Series Contents

Chapter III   Subassemblies & Module Descriptions

mini index

F. Power units, PU600C series

1. General description

The PU600C series power units are Continuum's state of the art MOSFET switching power supplies. These power units provide a current source to charge the capacitor bank for all our high rep rate systems up to 60 Hz. The PU610C is identical in construction to the PU620C except that the PU620C has a second HV converter board, which yields a higher power rating. The power rating for the PU610C is 1000 watts and the PU620C is 2000 watts. The PU630C units have a third converter board and a power rating of 3000 watts. All the power units have been designed to operate on international voltage levels so they are capable of running on 205-255Vac 3 phase or 205-255 Vac single phase.

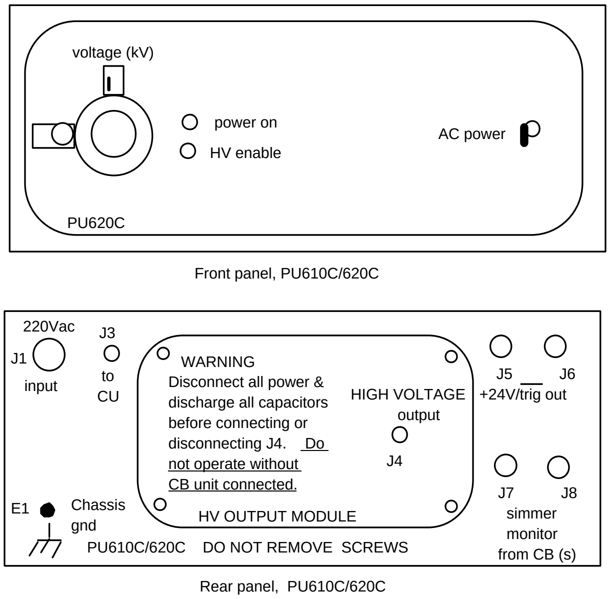
2. Structural Organization

The PU600C series each have two separate power supplies, the high voltage supply and the 24 volt accessory supply.

a) High voltage supply

- Charge voltage can be adjusted from - 800 volts to -1900 volts from the front panel. The high voltage output uses J4 on rear panel.
- The power units have internal voltage limiting (factory adjustable up to 2000 volts) in parallel with the front panel voltage adjustment. In addition, an OVP circuit stops the entire system in case of failure of the voltage adjustment circuit.

b) The 24 volt accessory output is provided by an internally mounted power supply mounted located next to the power unit logic PCBA. A small standby circuit turns on the 24 volt supply when a 2mA interlock signal (PU enable) is received from the control unit. This signal uses outputs J5 and J6 on the back panel. A µs +24 to 0 volt



PU610C/620C front & rear panels.

pulse on the +24 volt accessory output is for system rep rate synchronization. The function of the 24Vdc supply is to:

• power accessories

• open interlock relays in capacitor banks

• carry the "24 V to 0 V" synchronization signal to the capacitor banks for flashlamp triggering.

Front Panel

1) POWER ON red indicator light. This is the main power indicator. It comes on when the power unit is activated and line power is present.

2) HV ENABLE red indicator light shows that the system is in the **GO** mode and can be operated.

3) Voltage selector knob. This selects the capacitor bank charge voltage.

Rear Panel

1) J1 is the main power input of 205-255 Vac 3 phase or 205-255 Vac single phase 50/60 Hz.

2) J3 is the connection to Control Unit, CU601C. The “J3 to CU" connector receives the PU enable signal, charge and firing orders from the control unit. It also sends the end of charge signal to the CU601C. These units are optically isolated.

3) J4 is marked “HIGH VOLTAGE output”. This is a high voltage output which **must be connected to the high voltage input of the capacitor bank.** Type of connector: MHV.

4) J5 & J6 are identical 24V trigger outputs. For each power unit there are two 24V trigger outputs. One has to be connected to the J4 or J5 24V input of the capacitor bank which is charged by this power unit.

5) J7 & J8 sense the simmer status of the “C” version capacitor banks allowing reduced voltage triggering.

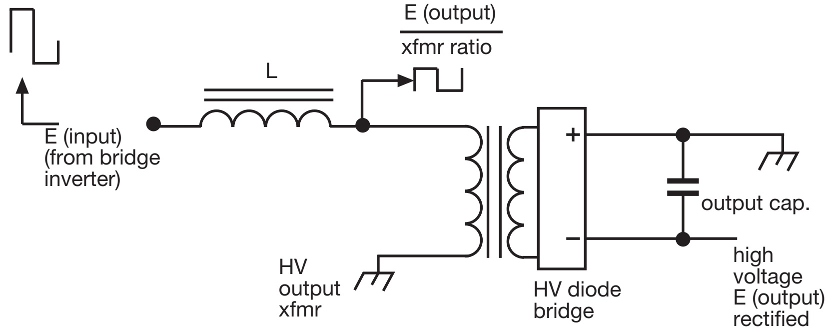
3. Principle of Operation

The power units use an off-line reactance-limited dc-dc converter to provide a controlled charging current to the capacitor bank. The capacitor(s) in the CB present a low impedance voltage source to the HV diode bridge whatever the charge voltage. This voltage is commutated by the HV diode bridge, when an alternating current source is applied - effectively creating a square wave voltage clamped by the output capacitor. This voltage is matched to the source voltage (the chopped waveform from the bridge inverter) by the high voltage output transformer. An inductor “L” is inserted between the inverter and the HV output transformer providing the reactance-limiting effect. The E_{IN} square wave is larger than the E_{OUT}/transformer ratio square wave (the difference is inversely proportional to the state of charge in the output capacitor). Therefore, at zero volts E_{IN} appears across L, yielding a triangular current waveform.

The peak current at zero volts output seen by the inverter is a function of E_{IN}, L and the frequency of the inverter.

As the capacitor charges, the (E_{OUT}/transformer ratio) voltage increases and the voltage across L decreases, causing the current in L to decrease correspondingly. Thus, for a fixed inverter frequency and fixed E_{IN}, L and the transformer ratio can be chosen to limit the inverter current to a specific value and provide a current source output to the capacitor bank.

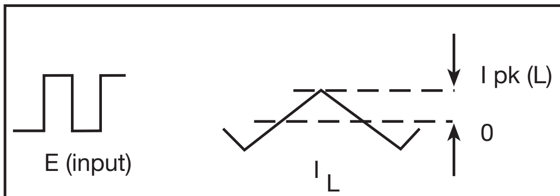
However, the current in L is also directly proportional to E_{IN}. If the frequency is fixed, the circuit would provide very low output power at low input voltage and excessive output power at high input voltages, limiting the practicality of the application. Therefore, since the current in L is inversely proportional to the frequency of the inverter, a voltage-controlled oscillator (VCO PCBA schematic) is used to provide the inverter’s clock signal. The VCO derives its control voltage from the dc voltage feeding the HV converter PCBA(s). As more voltage is available



Reactance-limiting inductor L.

(when the ac line voltage is high), the frequency of the inverter increases. This has the effect of lowering the current in L and thus the output current of the power unit. An undervoltage cutoff is also provided in the VCO PCBA to avoid laser operation in brown-out conditions.

The reactance-limited converter is controlled by the power unit logic PCBA which receives optically-isolated commands from the logic unit.

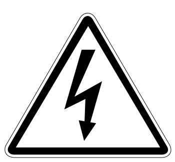


Short circuit operation (zero volts output).

Operation is initiated by the charge command and ended by an internal sensing circuit (see HV sense schematic). A safety overvoltage cutoff is provided protecting the capacitor banks from overvoltage. If the over-voltage cutoff is activated, a red LED (labeled OVP on PU Logic board, page 3-50) on printed circuit board is illuminated. The power unit logic board will also issue a “fault” indication if:

a) a MOSFET thermostat opens, or

b) the power unit remains active for a period longer than needed to charge the capacitor bank (this is to detect a short circuit on the output, since the inverter normally drives a “short circuit” each time it charges the capacitor bank).

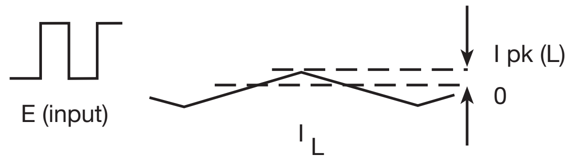


WARNING!! DANGEROUS VOLTAGE!!

LETHAL VOLTAGES MAY EXIST IN THIS SYSTEM AT ANY TIME!

When the internal sense circuit detects the correct charge voltage, it latches “off” the inverter and issues an optically isolated “end of charge” signal to the logic unit. The logic unit then returns a “fire” signal to the power unit.

When the fire signal is received, a pulse is issued to Q7 on the power unit logic board, which briefly shorts the +24/trigger output to common. This triggers an adjustable delay in the capacitor bank.



Reduced I pk (L) as E (output) rises.

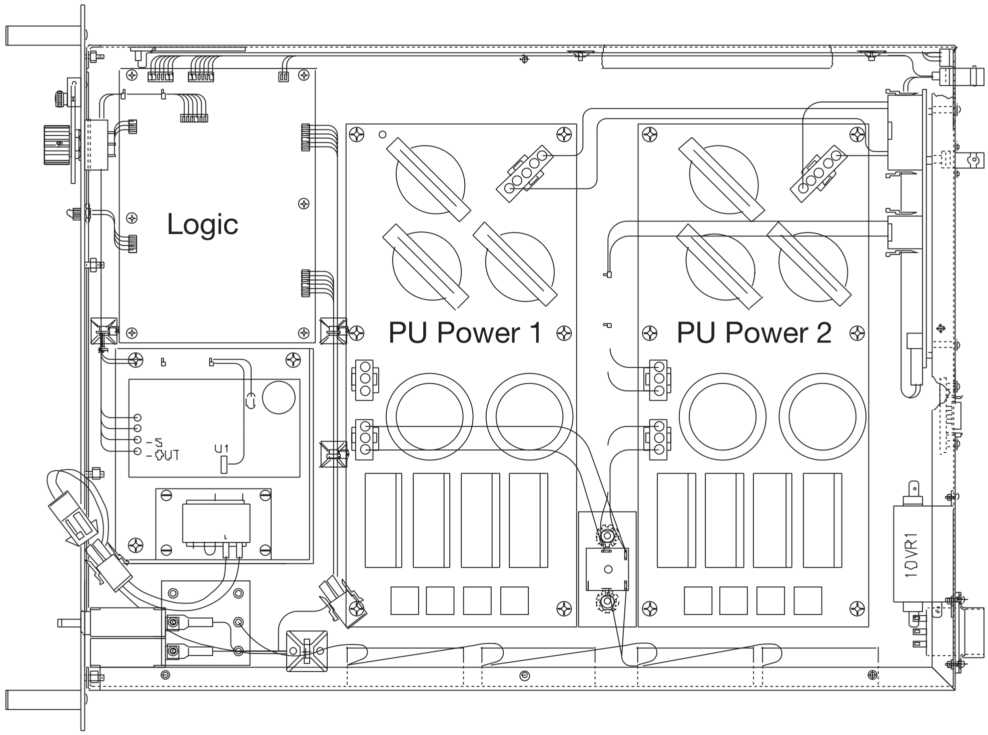
A number of protective circuits are provided to assure correct operation of the power unit. There is the optically isolated “power unit enable” input which turns on the +24V internal power supply and enables the power units to operate. This permits complete control of the power unit and capacitor bank from the logic unit. There is also an under voltage cutoff circuitry on internal supply voltages to prevent abnormal operation of the inverter.

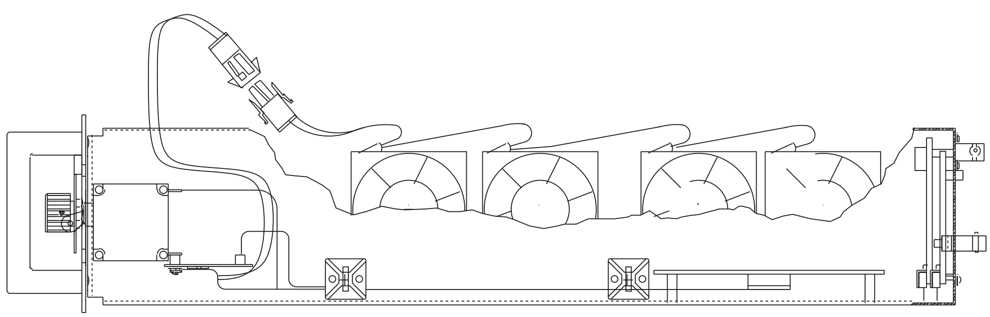
Part of the circuit is connected directly to the 205-255 volt power line. Measurements should be made only with test instruments having a differential input. Do **NOT** attempt to make single ended oscilloscope measurements by “floating” the oscilloscope with an isolation transformer.

mini index

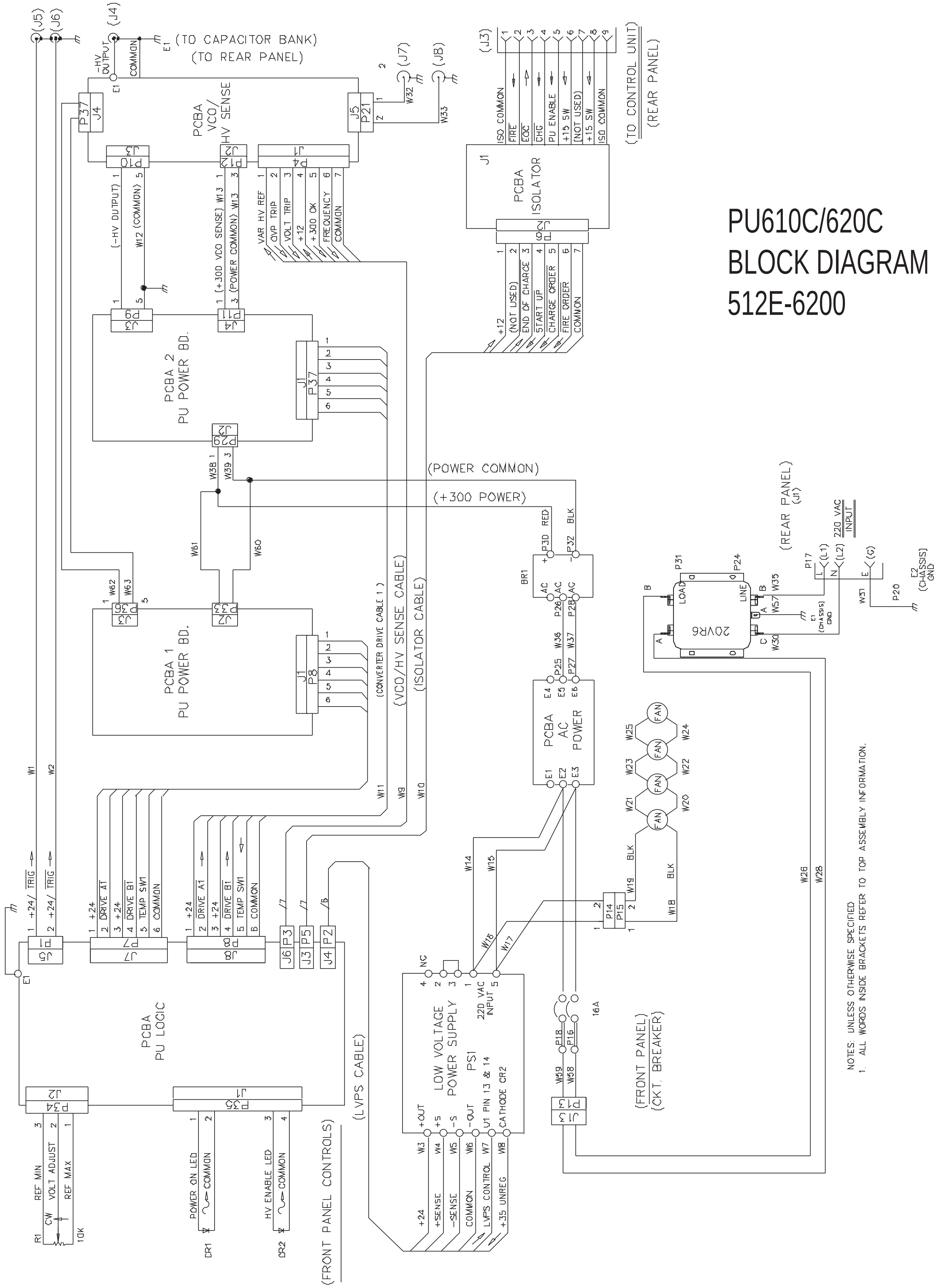
4. Connections and Signals

The power unit gets its power from the electronics cabinet's main ac bus which has a 20A breaker. It receives its charge and fire commands from the control unit which sets the clock frequencies and verifies system securities.

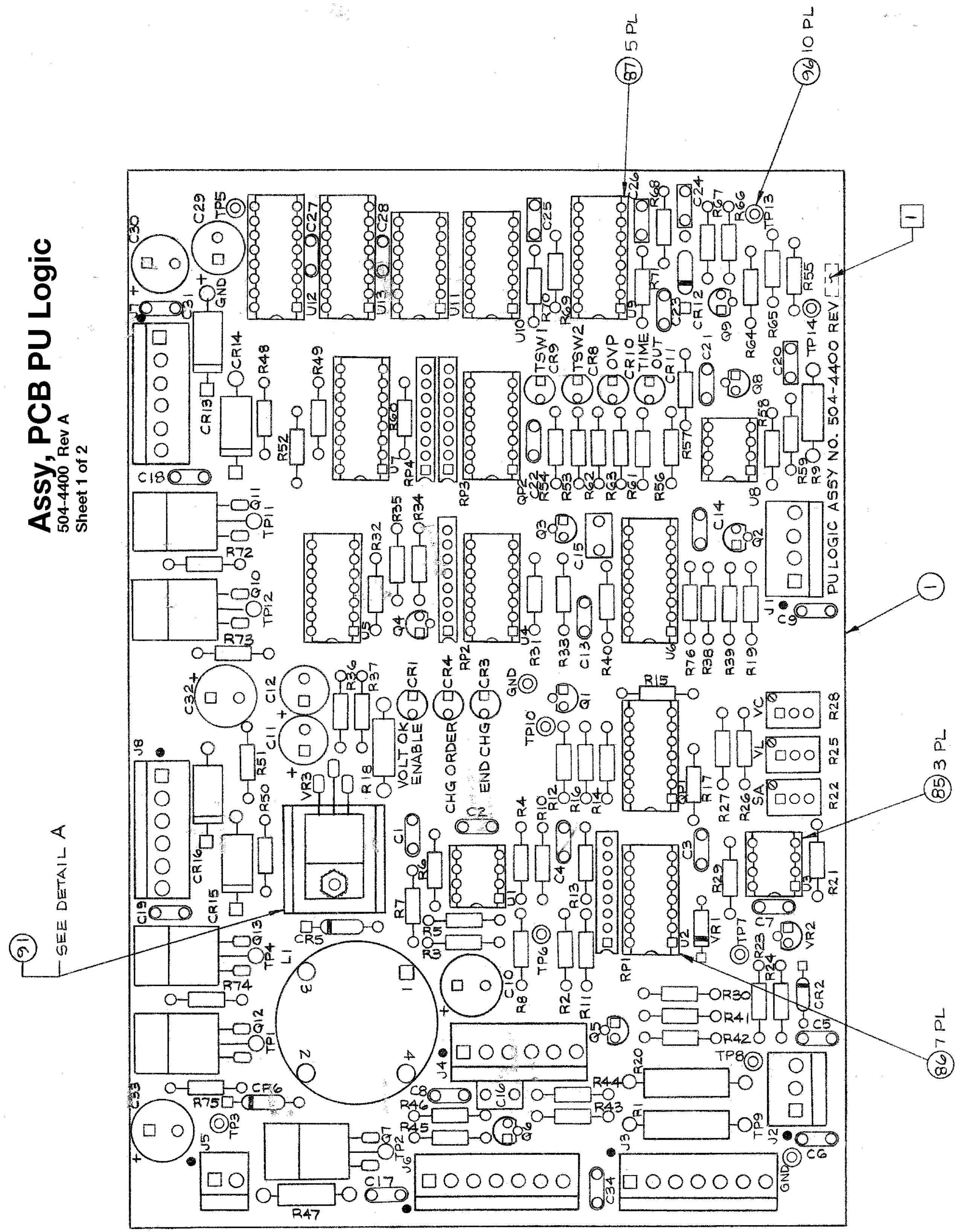




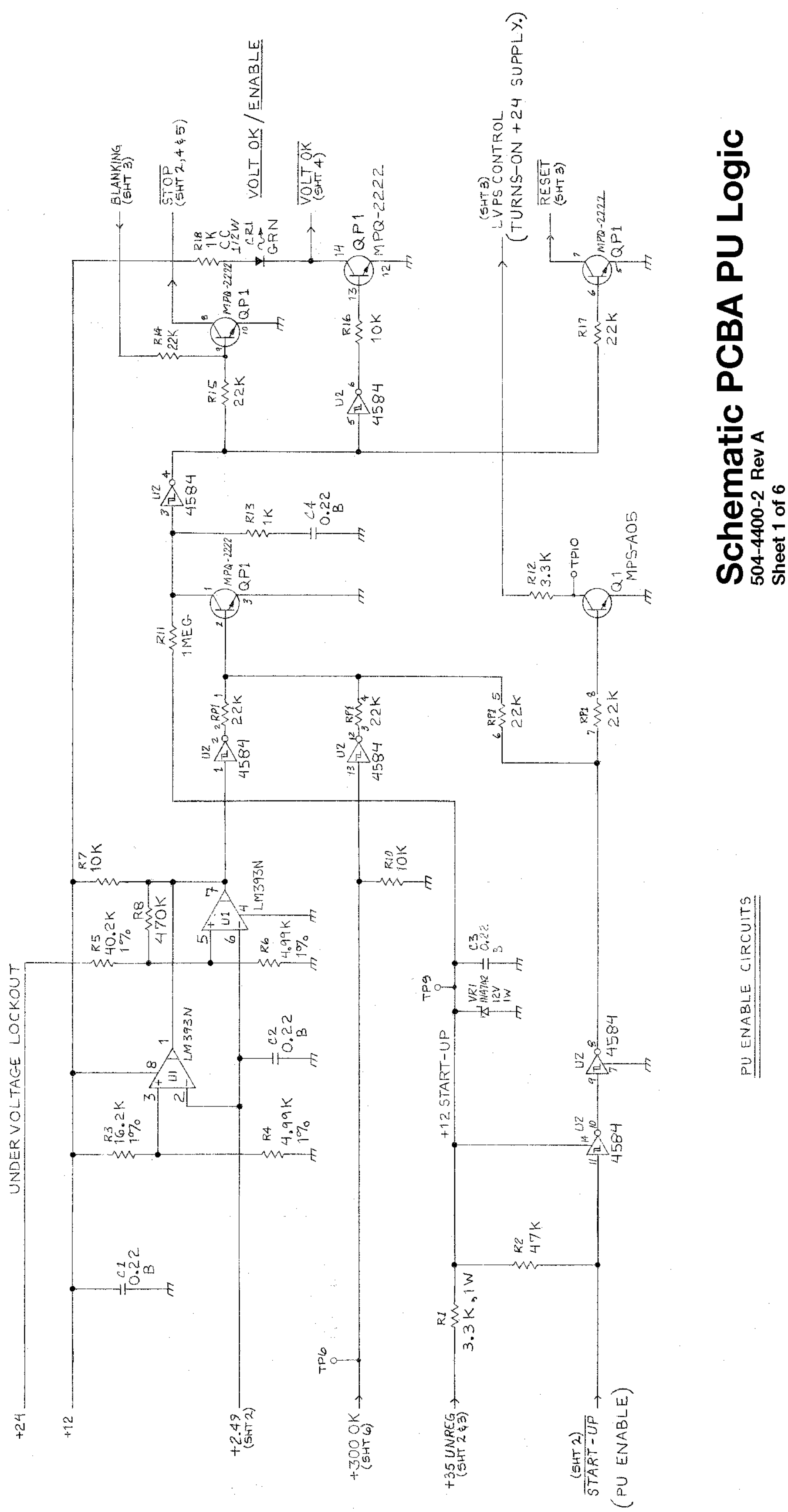
PU620C Chassis

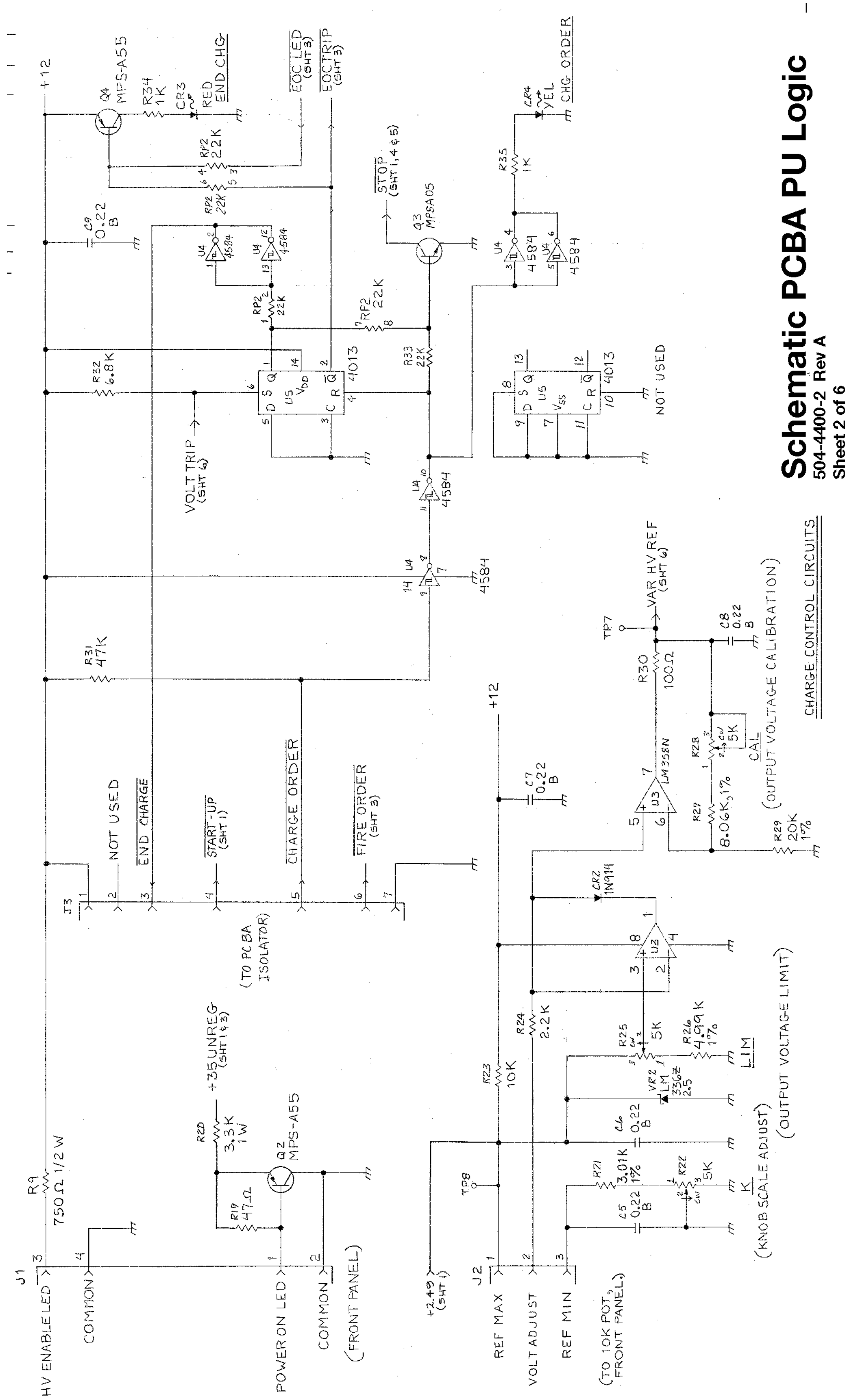


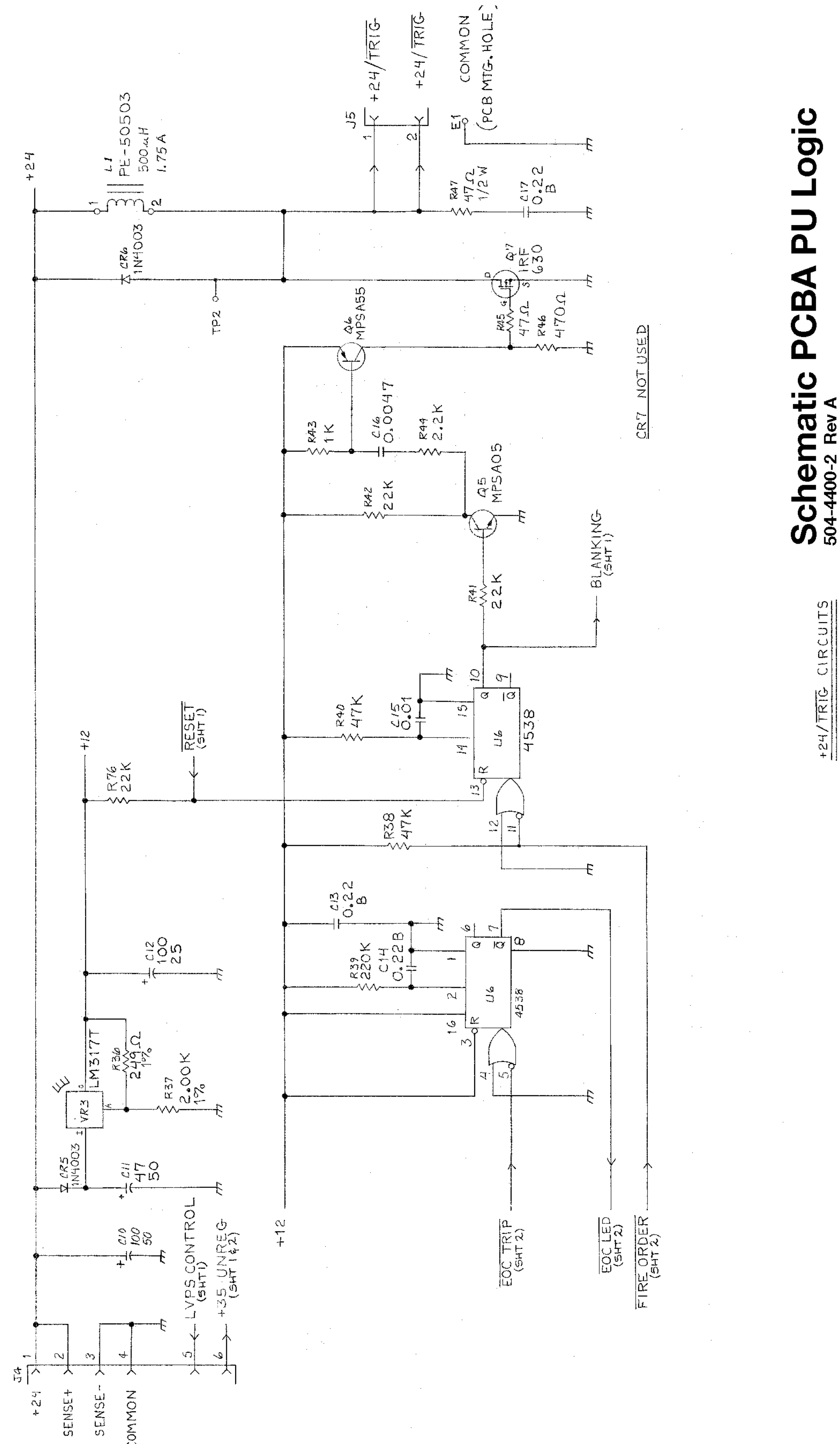
PU610C/620C
BLOCK DIAGRAM
512E-6200



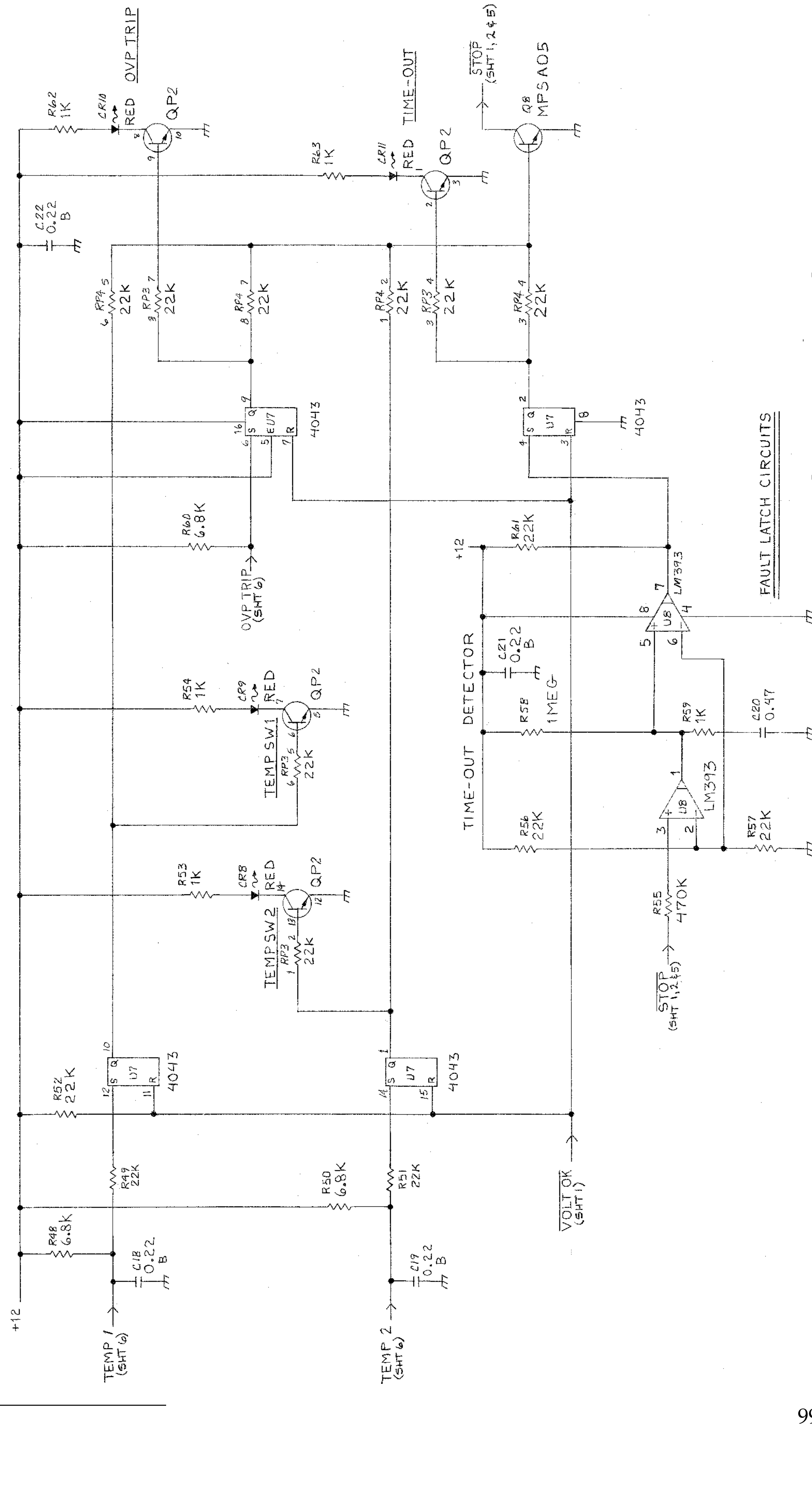
Assy, PCB PU Logic
504-4400 Rev A
Sheet 1 of 2


Schematic PCBA PU Logic
504-4400-2 Rev A
Sheet 1 of 6
PU ENABLE CIRCUITS

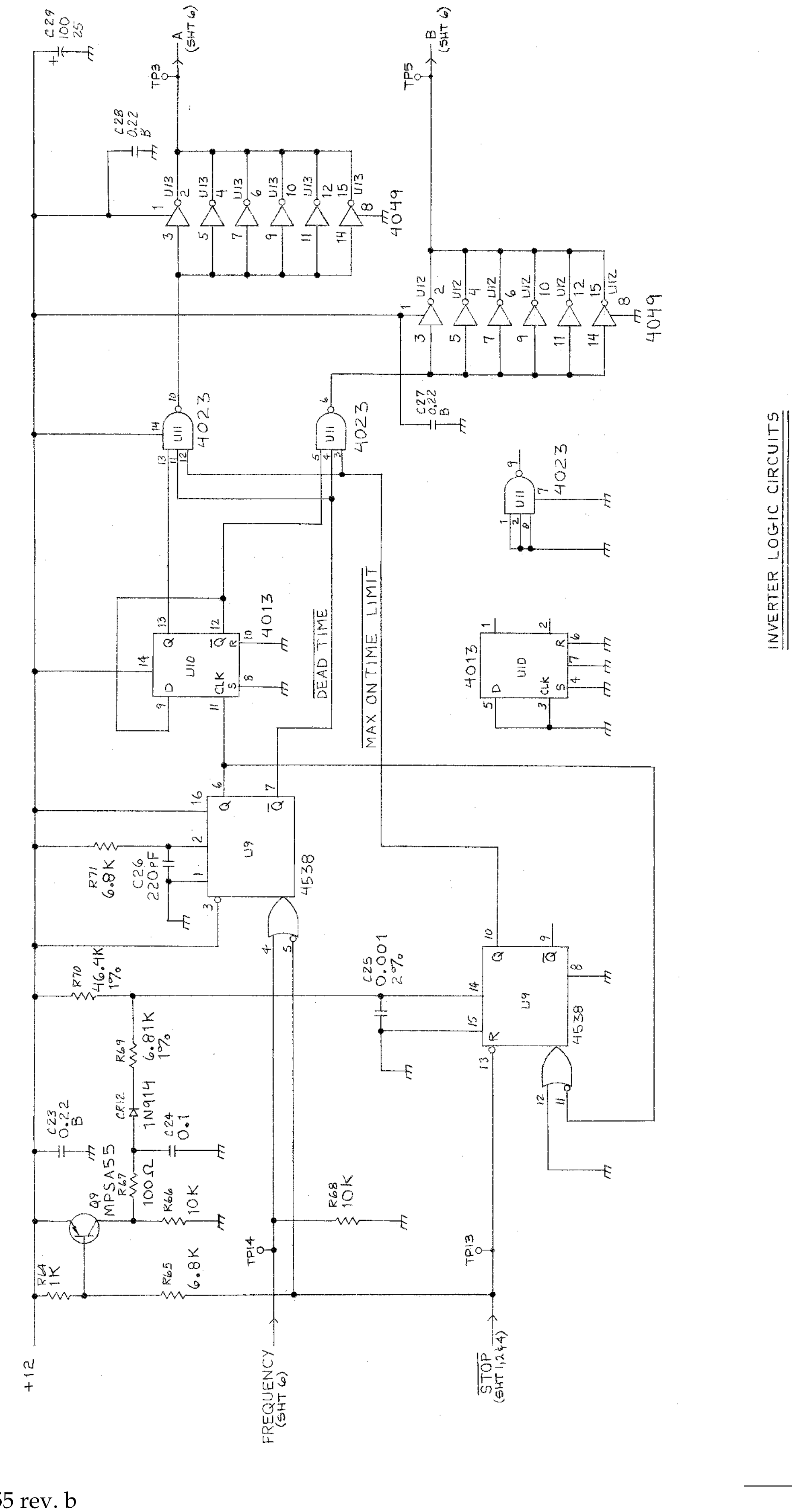

Schematic PCBA PU Logic
504-4400-2 Rev A
Sheet 2 of 6
CHARGE CONTROL CIRCUITS



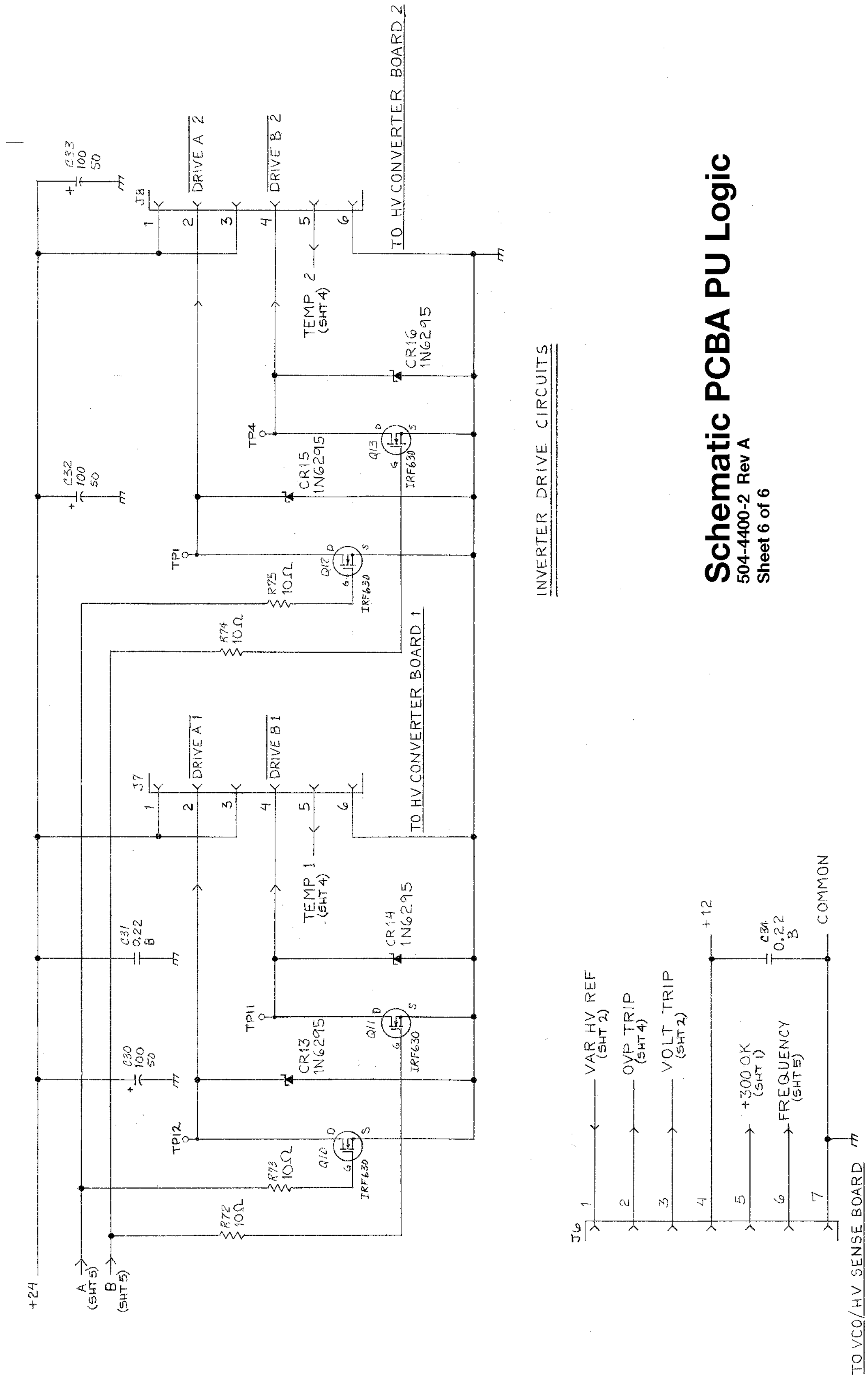
Schematic PCBA PU Logic
504-4400-2 Rev A
Sheet 3 of 6



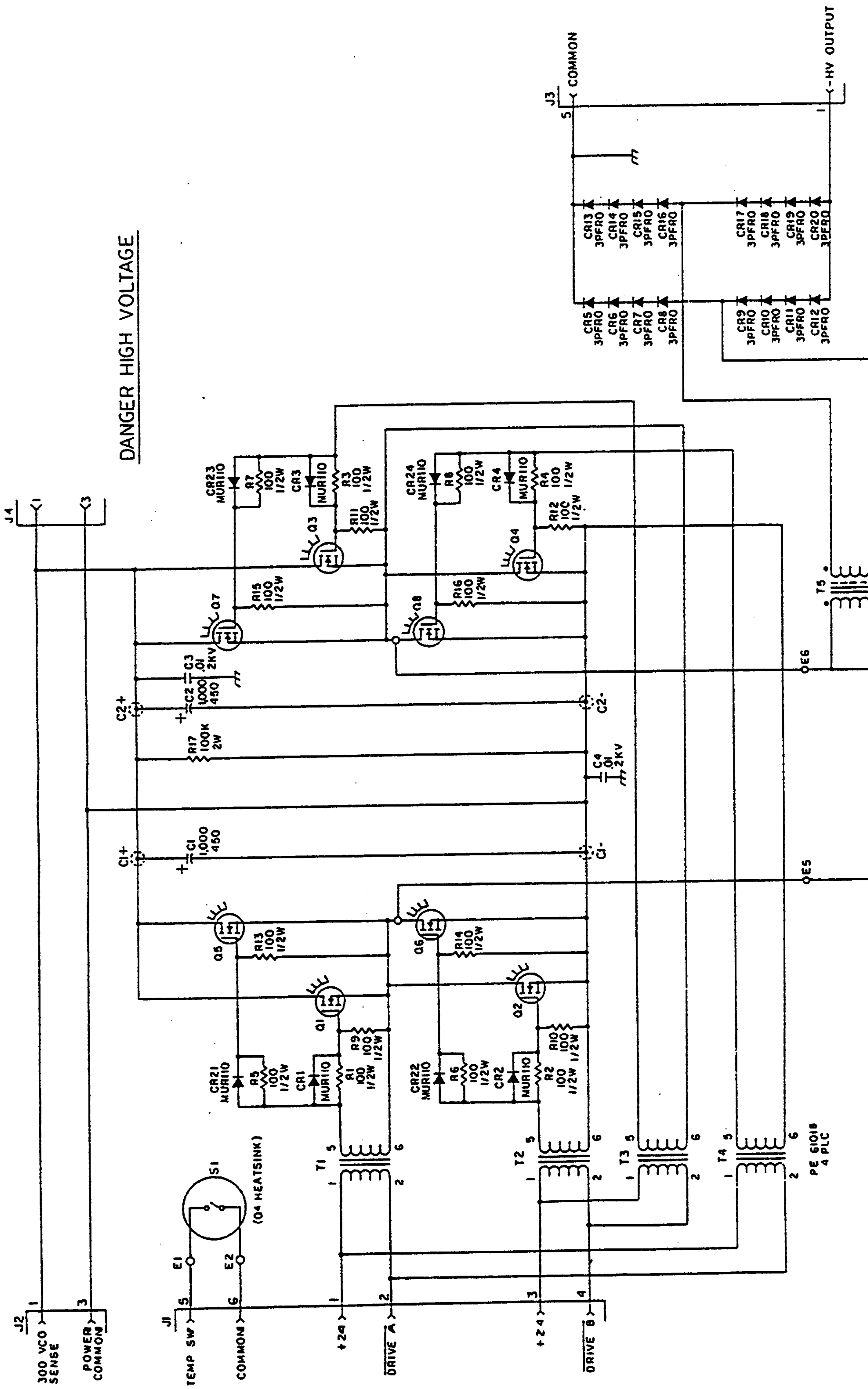
Schematic PCBA PU Logic
504-4400-2 Rev A
Sheet 4 of 6



Schematic PCBA PU Logic
504-4400-2 Rev A
Sheet 5 of 6

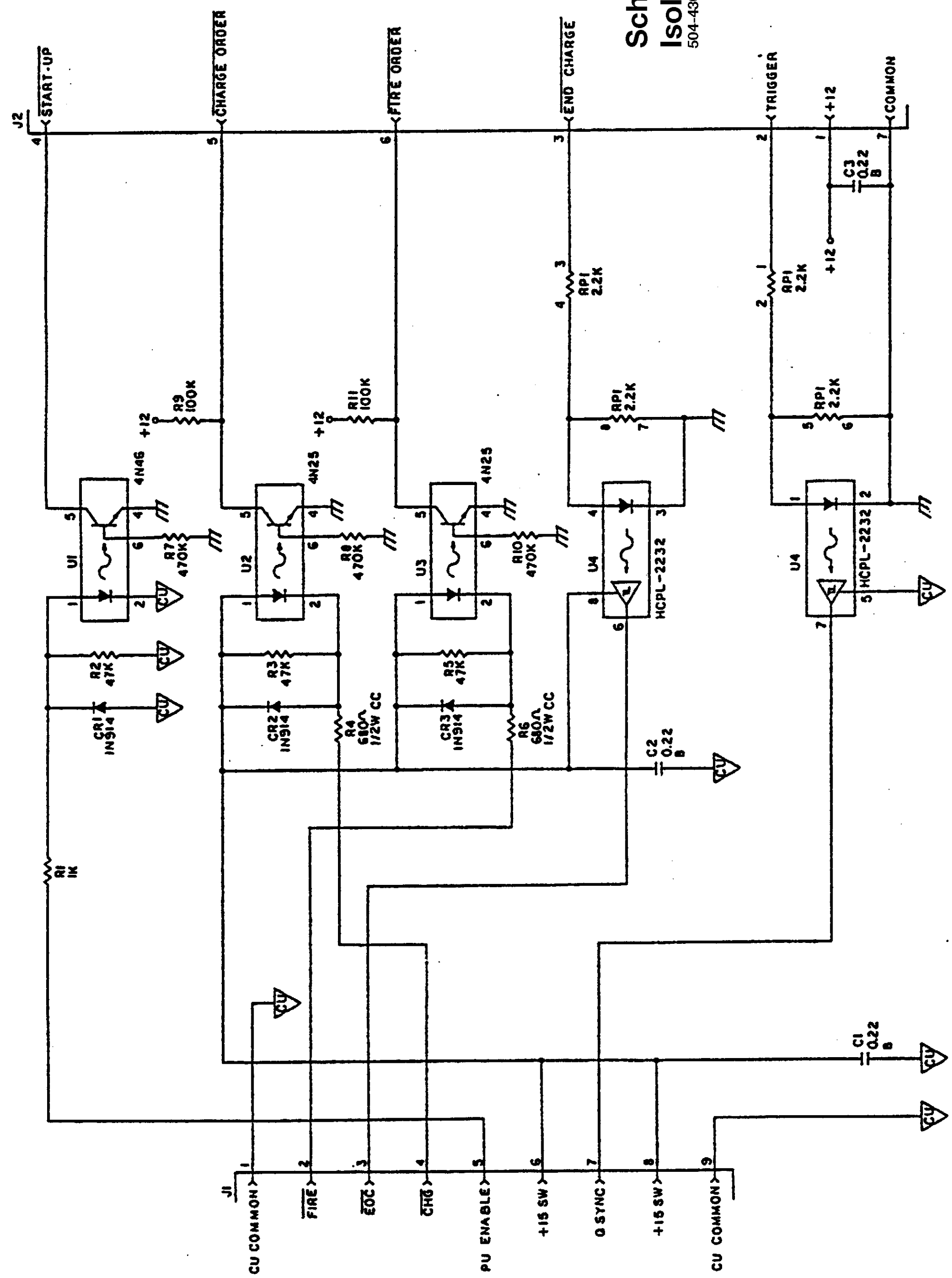


Schematic PCBA PU Logic
504-4400-2 Rev A
Sheet 6 of 6

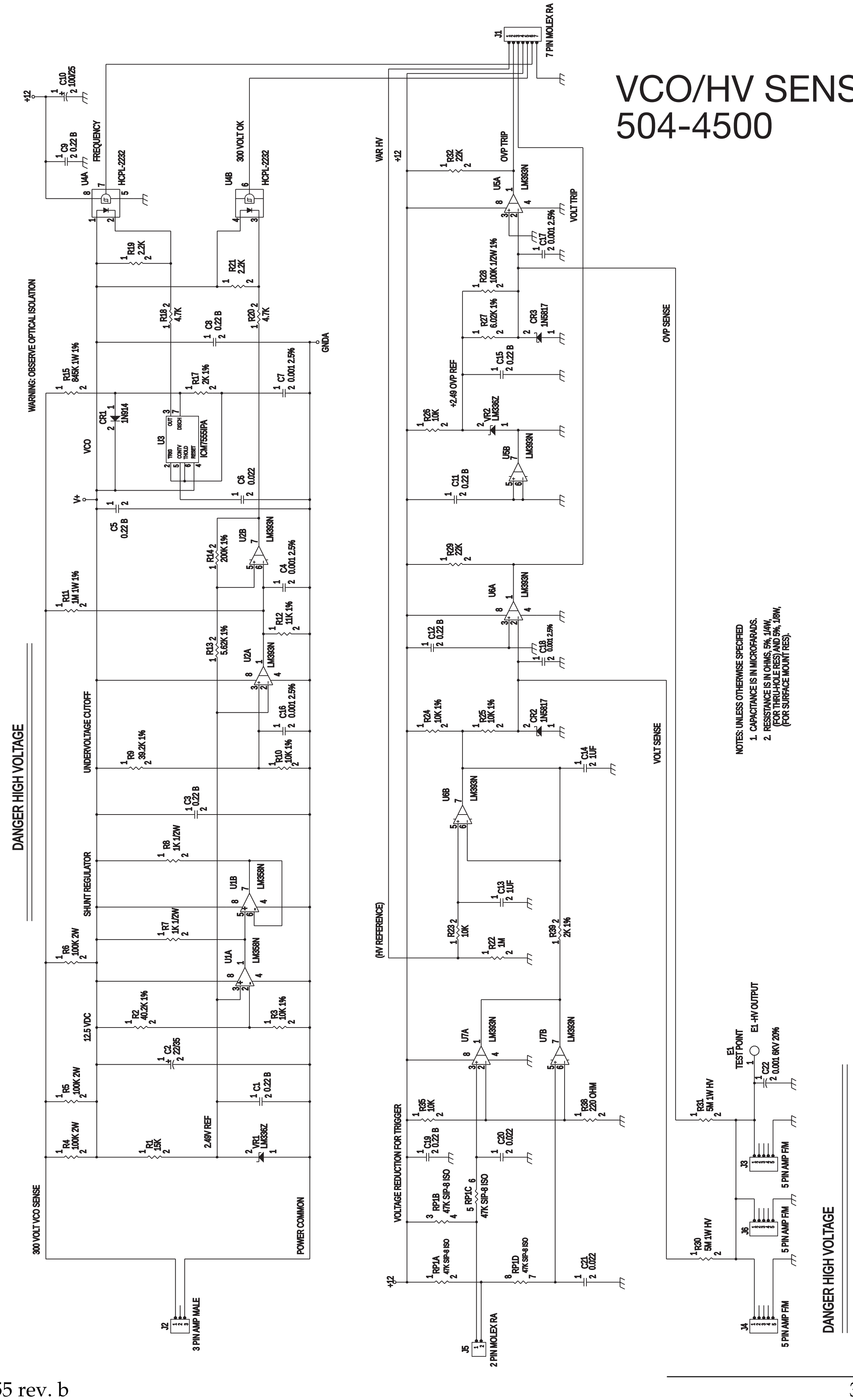


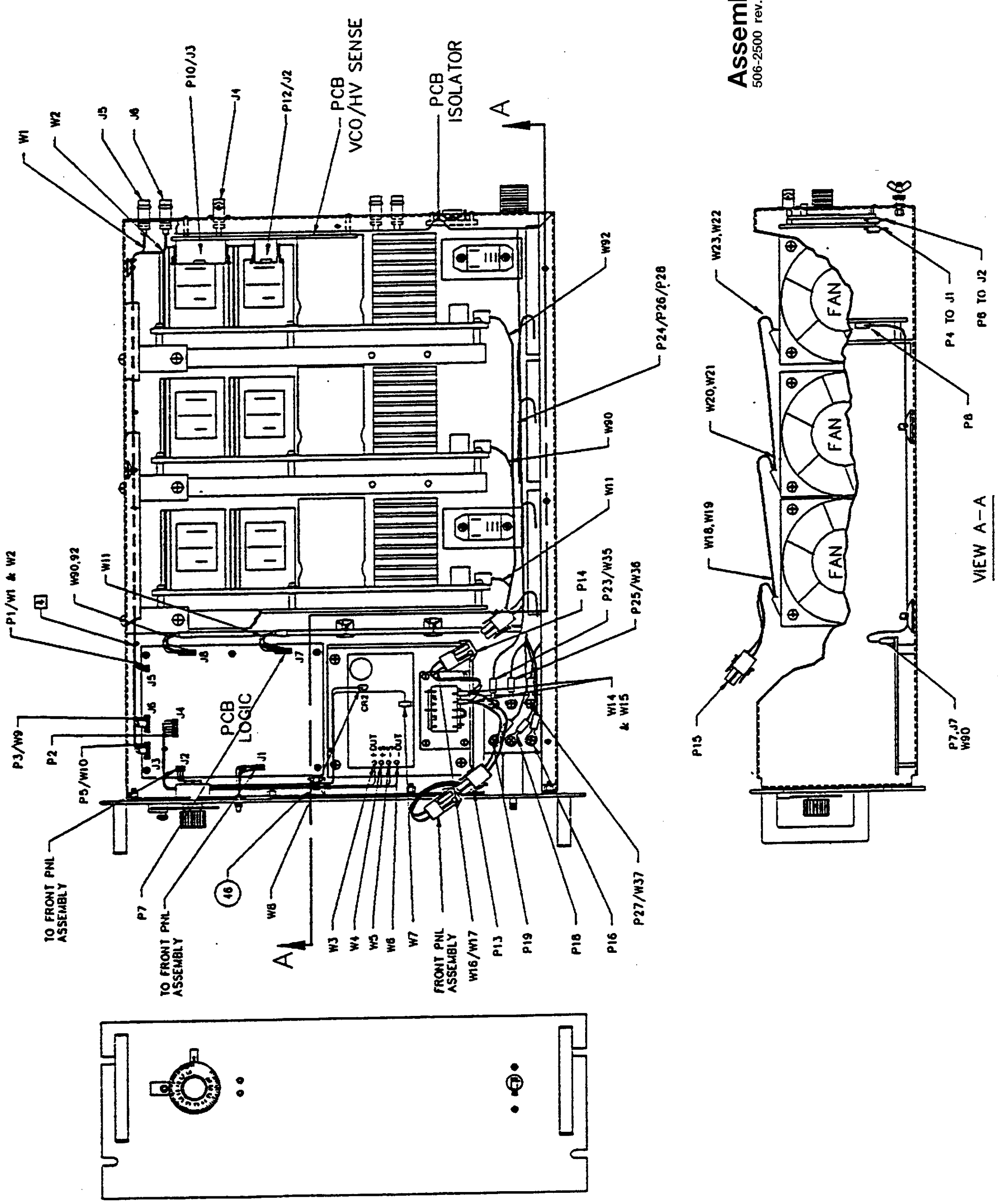
Schematic PCBA
PU Power Board
504-4200-2 rev. C

Schematic Drawing
Isolator
504-4300-2 rev. A

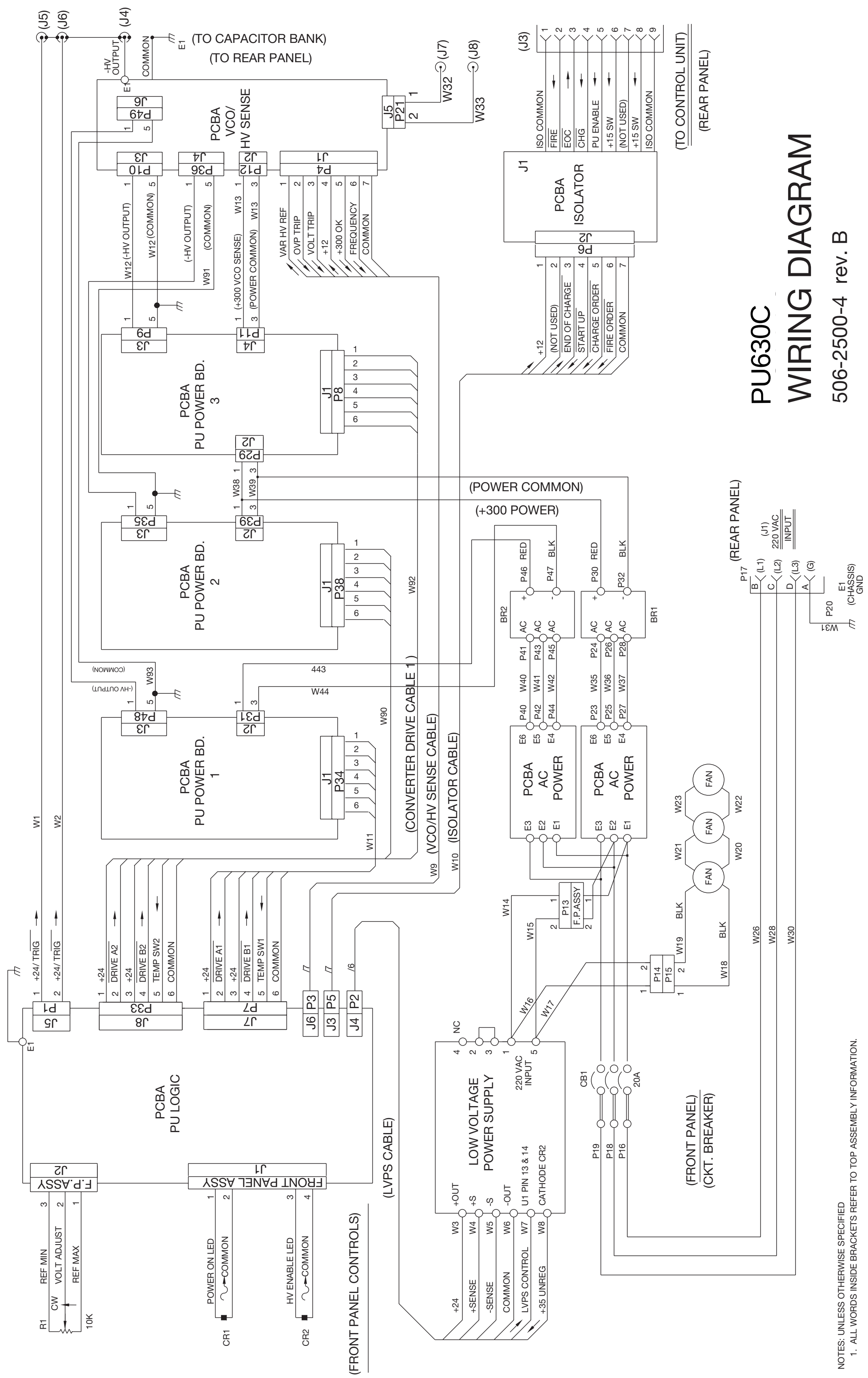


VCO/HV SENSE
504-4500





Assembly, PU630C
506-2500 rev. B


PU630C
WIRING DIAGRAM
506-2500-4 rev. B
NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL WORDS INSIDE BRACKETS REFER TO TOP ASSEMBLY INFORMATION.

Chapter III   CB600C Series Contents

Chapter III Subassemblies & Module Descriptions

G. CB600C series simmer capacitor banks

mini index

1. General Description

The Continuum simmer capacitor banks are designed for use in Continuum's line of high repetition rate laser systems. The capacitor banks store the energy needed to run the flashlamps. The H series capacitor banks are compatible with the C series power units.

They also convert the 24 volt trigger pulse from a power unit to a high voltage spike to initiate ionization in the flashlamps. Safety interlocks ensure that the cable to the laser bench is firmly connected.

2. Structural Organization

When you open a Continuum capacitor bank, the main capacitor is mounted in the middle of the chassis (see page 3-70). The trigger board is standing on its side in the left of the chassis next to a large transformer. In the right rear corner of the chassis are the power relay, rf line filter and fuses. The laser head cable comes in through the rear panel.

In the rear of the chassis is the high voltage PCBA. The function of this circuit board is to isolate the power unit from the high voltage capacitor and discharge the capacitor in the absence of the +24V. Discharge time through the dump resistors is <10 ms, but in the event of a failure of this circuit, a permanently mounted 10 MΩ resistor will discharge the capacitor in ~1 minute. Whenever working on the system, safety precautions should be taken to ensure that there is no residual voltage on the capacitors.

At startup the power relay opens allowing the CB to charge, and then at shutdown the capacitors discharge through resistors. This is done at shutdown to assure that there is no hold-over energy left in the capacitors.

Front Panel

The front panel of the capacitor bank has two red indicator lights marked **POWER ON** and **SIMMER**. There is also a **DELAY ADJ** dial.

Rear Panel

1) The **HIGH VOLTAGE** input **J3**, must be connected to the power unit through the high voltage output.

2) **J4 CU sync out** has a variable trigger output which is adjustable using the **DELAY ADJ** on the front panel. This "CU sync out" is different than the "24 V/trig out" and must not be used to trigger other capacitor banks.

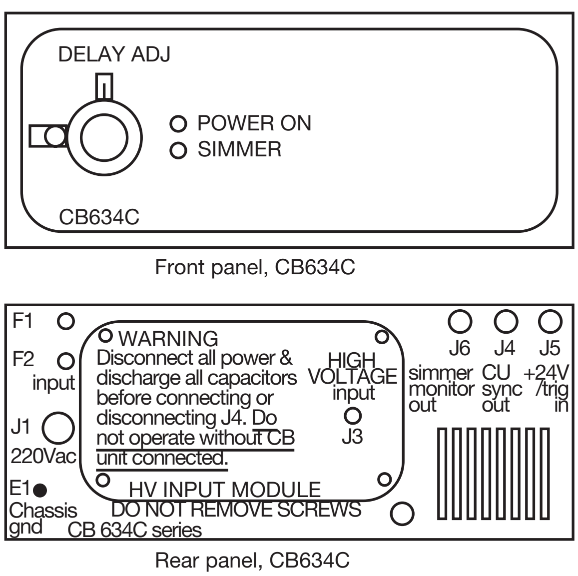
3) "J5 +24V/trig" connects to the power unit for triggering. It carries a synchronization signal which triggers the firing of the laser head.

4) The 200-240 Vac input must be connected to the 3 pin MS series connector marked "J1 input 220 Vac" on the far left hand side of the rear panel.

5) The two fuse holders marked **F1**, **F2** for the 200-240 Vac input are 1.5 A slo fuses.

6) A grounding lug marked **E1** Chassis gnd, on the lower lefthand corner of the rear panel is the electrical/chassis ground. Grounding straps must be used to connect this chassis to the corresponding grounding lugs on the control unit and the power units.

7) These panels of the C series capacitor banks have a **J6** BNC plug. This J6 "simmer monitor out" cable connects to the simmer monitor plug on the power units.



CB634C front & rear panels.

3. Principle of Operation

The capacitor banks have a current source power supply for simmer operation. The current source power supply consists of logic to monitor simmer operation, a conventional switching power supply to produce the current for simmer operation (see pages 3-74 & 75) and an under voltage detector for the +24V and the unregulated -600V. Q5 will be biased off if the +24V is low and Q6 will be biased on if the -600 V under regulator is low. U2 monitors the simmer current when simmer current is low. Output of U2 pin 1 goes low when the simmer current is correct. The current source power supply consists of a PWM 3524 Pulse Width Monitor (U3), switching transistors Q3 and Q4. The sense resistors R6-R10 monitors the current for the U3 which controls the duty cycle as a function of load requirement.

The schematics of the circuit are shown on following pages. Three inputs are required by the capacitor banks:

1) The power unit provides the current to charge the capacitors to a high voltage of <-2000 volts.

2) Single phase 205-255 volt power is used for the current source supply to simmer the lamps.

3) The 24 volts is used both for controlling the security loop and to carry the trigger order from the power unit to the capacitor bank.

Security Loop

1) The 24 volts provides power to activate relay K1 (page 3-78) as part of the security loop. Interruption of the security loop is accomplished by breaking the common line that goes through the power head. When the common line is interrupted, 24 V is removed from the HV relay and the high voltage capacitors are discharged through the resistor bank and K1 (located on the HV input PCBA).

2) Relay K1 connects the high voltage from the power unit to the capacitor bank. The relay ground circuit is completed by connecting the head cable to its laser bench connector. The capacitor cannot be charged if the head cable is not connected. Turning off relay K1 causes the capacitor to be discharged through a resistor bank R1-R4.

Trigger Circuit

The trigger PCBA (see schematics p. 3-76 & 77) contains logic circuitry to monitor for simmer or non-simmer (U5 & U6). Output signals indicate "POWER ON" and simmer/non-simmer operation, (J4). The front panel "Delay Adj" adjusts the firing of the flashlamps and the delay (50-550 µs) of the J4 CU sync out found on the rear panel. The +750 V power supply

CAUTION:

*Do **NOT** interchange J4 and J5. The output of J4 must not be used to trigger other CB630C's!*

will charge C13-C16. The delay signal (U3, U6, Q12) will trigger Q2 through Q1. This turns on the SCR Q2 by pulling the gate positive. Capacitors C13 through C16 have been previously charged by the +750 volt supply. Turning on Q2, in effect, connects these capacitors directly across the primary coil of the trigger transformer. This induces a 17 kV spike in the secondary coil.

However, the flashlamp will ionize before this voltage is reached. The ionized flashlamp discharges the main capacitor to cause the high intensity light flash.

Conduction path for the high current discharge is from the capacitor through the saturated transformer T2, then through a coaxial cable to the flashlamp. Return current is carried through the cable shields back to the capacitor bank chassis.

4. Connections and Signals

The capacitor banks get their high voltage from the power unit (see the wiring diagram pages 3-72 & 79). The head cable of the first capacitor bank leads to the oscillator head and its flashlamps.

The second capacitor bank has its head cable attached to the amplifier head to power its flashlamps.

The power lines can be seen on the wiring diagram. All grounding lugs of the electronics in the rack are connected to each other and the laser table. Each unit is grounded through the power cable to the power line ground.

The CB600C series are all one channel units. Their total capacitances are as follows:

CB630C	18 µF
CB631C	30 µF
CB634C	30 µF & 18 µF

A CB630C can power two linear flashlamps delivering a total of 30 joules at 1.83 kV while the CB631C delivers 50 joules at 1.83 kV and the CB632C 84 joules at 1.83 kV.

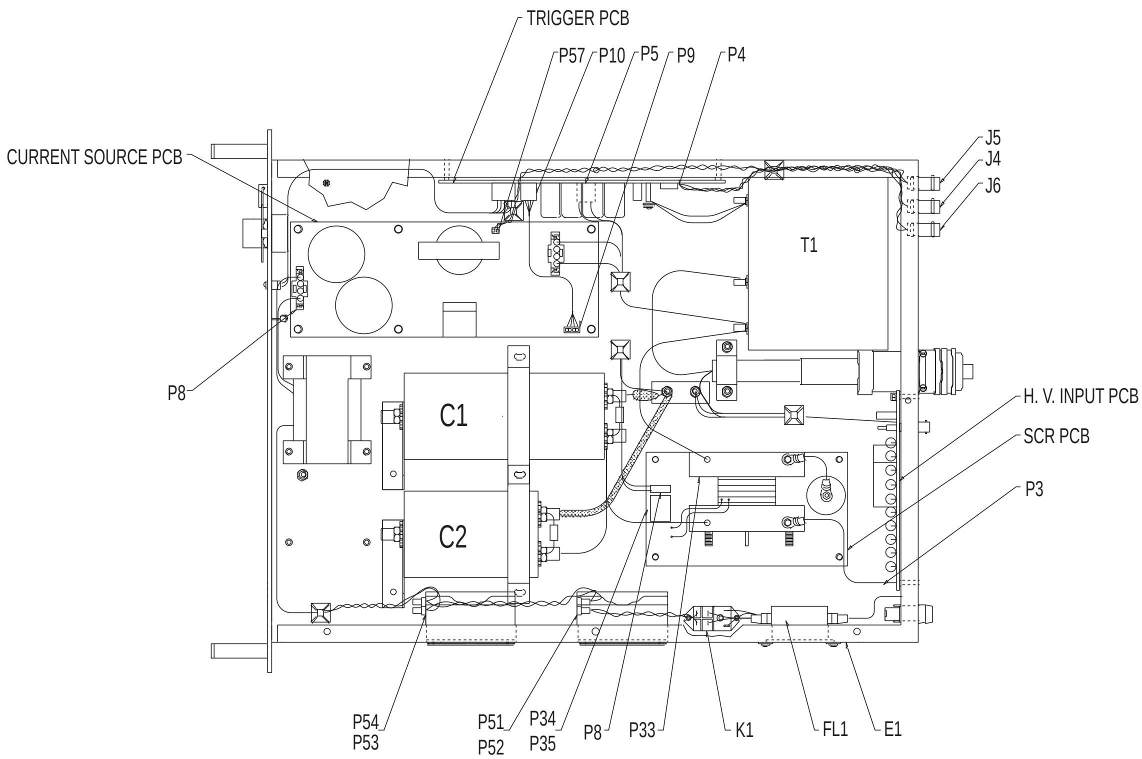
All Continuum's capacitor banks have a 24V trigger input which carries the synchronization signal from the power unit. All models of the CB600C series have a pulse delay time that is adjustable from 50 to 550 µs by the potentiometer which is on the front of the power unit.

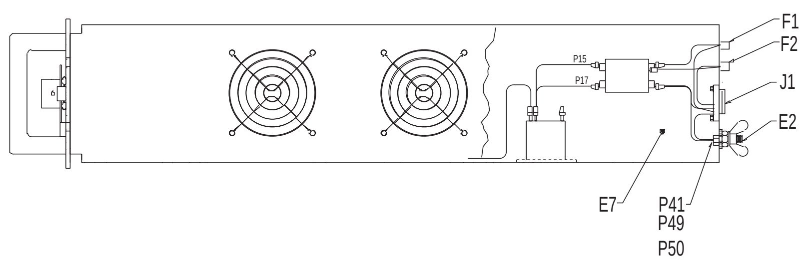
5. Service Instructions

WARNING!!

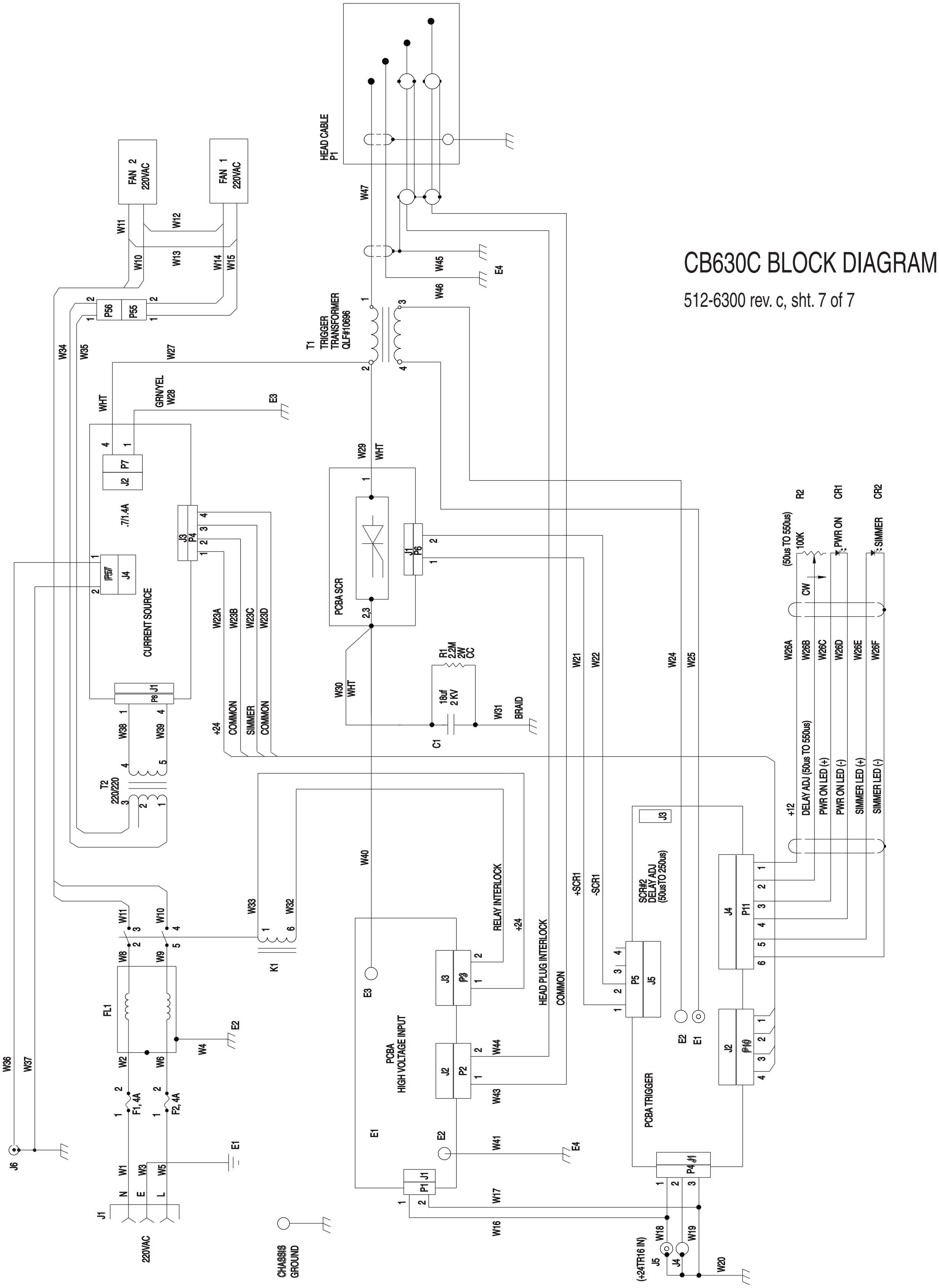
The CB capacitor banks contain high voltage capacitors which store a potentially lethal electrical charge indefinitely. Observe these precautions:

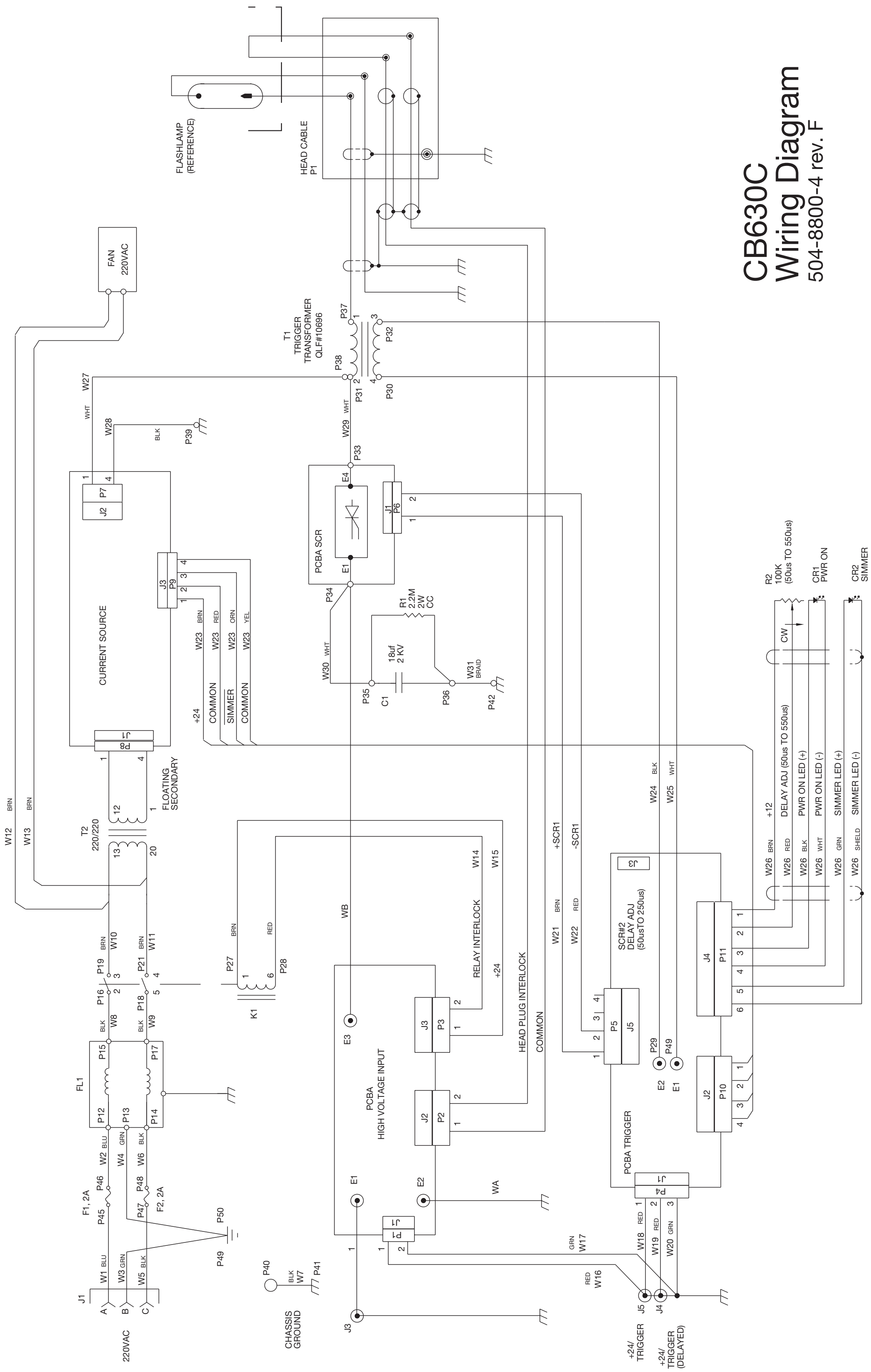
- Disconnect **all** cables including the laser head plug and 220 Vac input before working on the unit.
- Ensure that the capacitors are at ground before working on the unit using a 100 Ω 250 watt resistor (ground bar).
- Remove all metallic objects (rings, watches) and preferably use only one dry hand in an insulated glove, to work on the circuits. **DO NOT** work on circuits in the CB units without **FIRST** contacting our service department.
- Call Continuum service department if there are any questions about safety procedures for working on this unit.

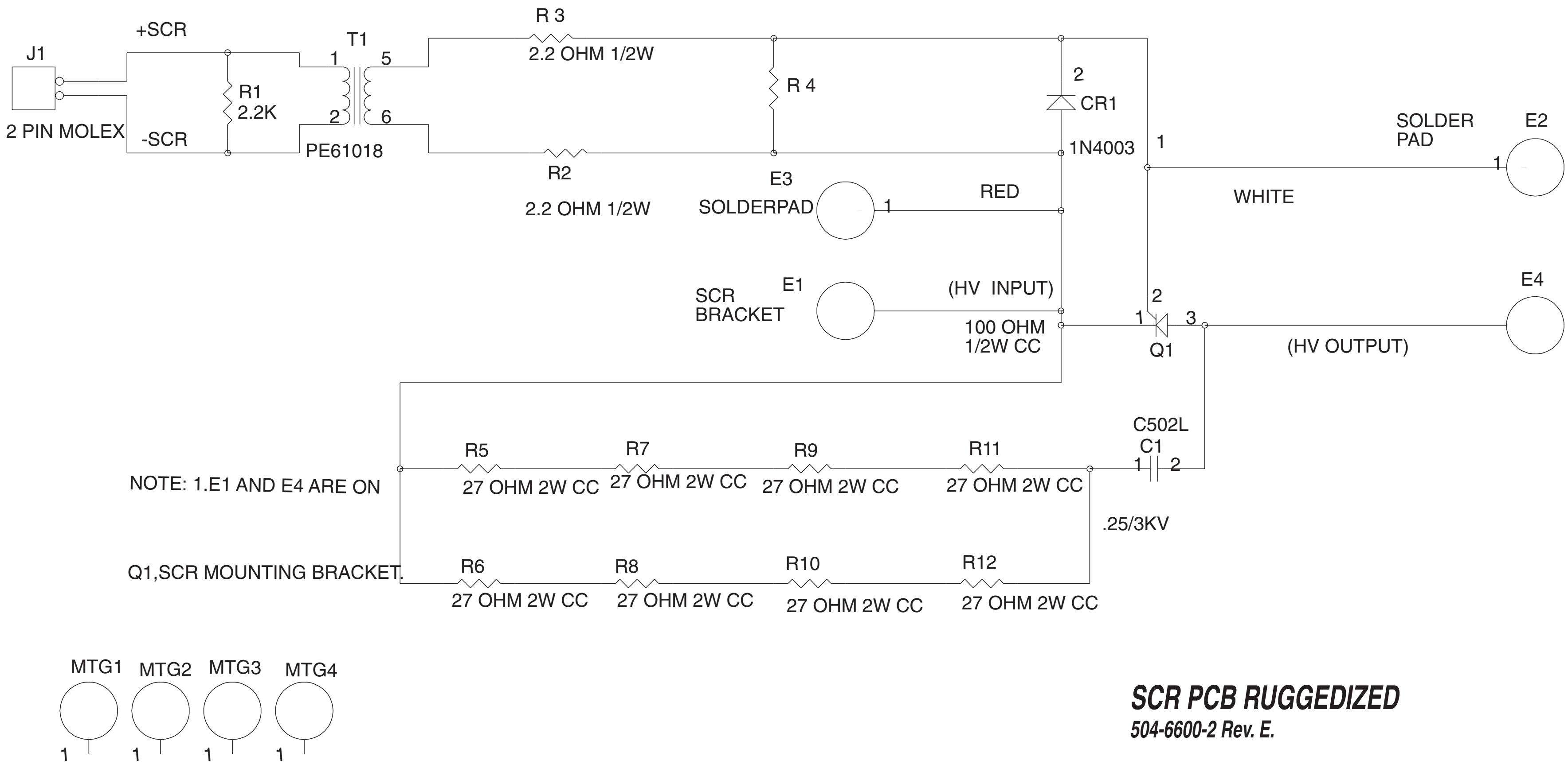




CB634C
512-6340

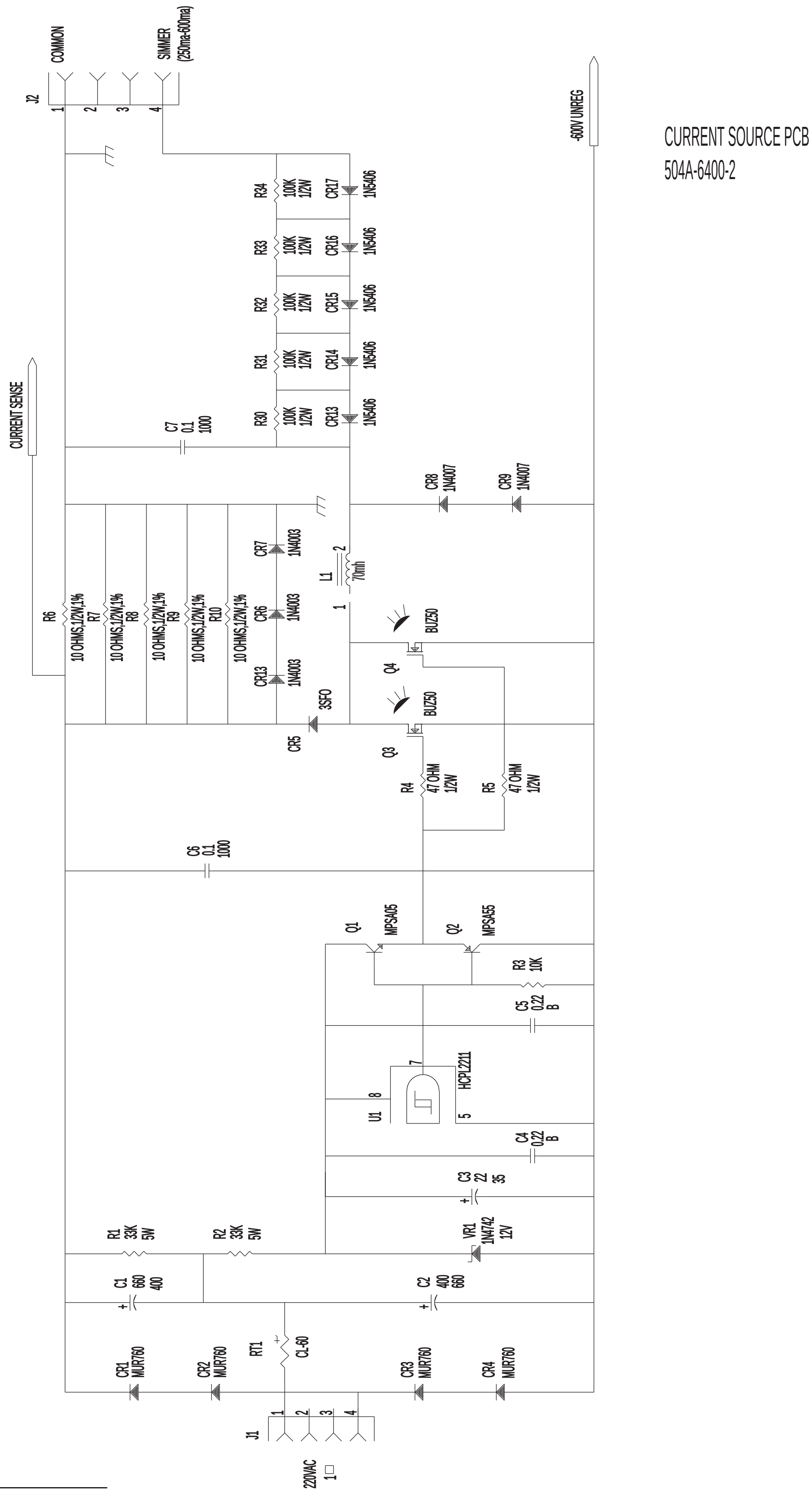

CB630C BLOCK DIAGRAM
512-6300 rev. c, sht. 7 of 7
HEAD CABLE
P1
T1
TRIGGER
TRANSFORMER
QLF#10696
FAN 2
220VAC
FAN 1
220VAC
CURRENT SOURCE
PCBA SCR
PCBA
HIGH VOLTAGE INPUT
PCBA TRIGGER
RELAY INTERLOCK
HEAD PLUG INTERLOCK
CHASSIS
GROUND
220VAC


CB630C
Wiring Diagram
504-8800-4 rev. F

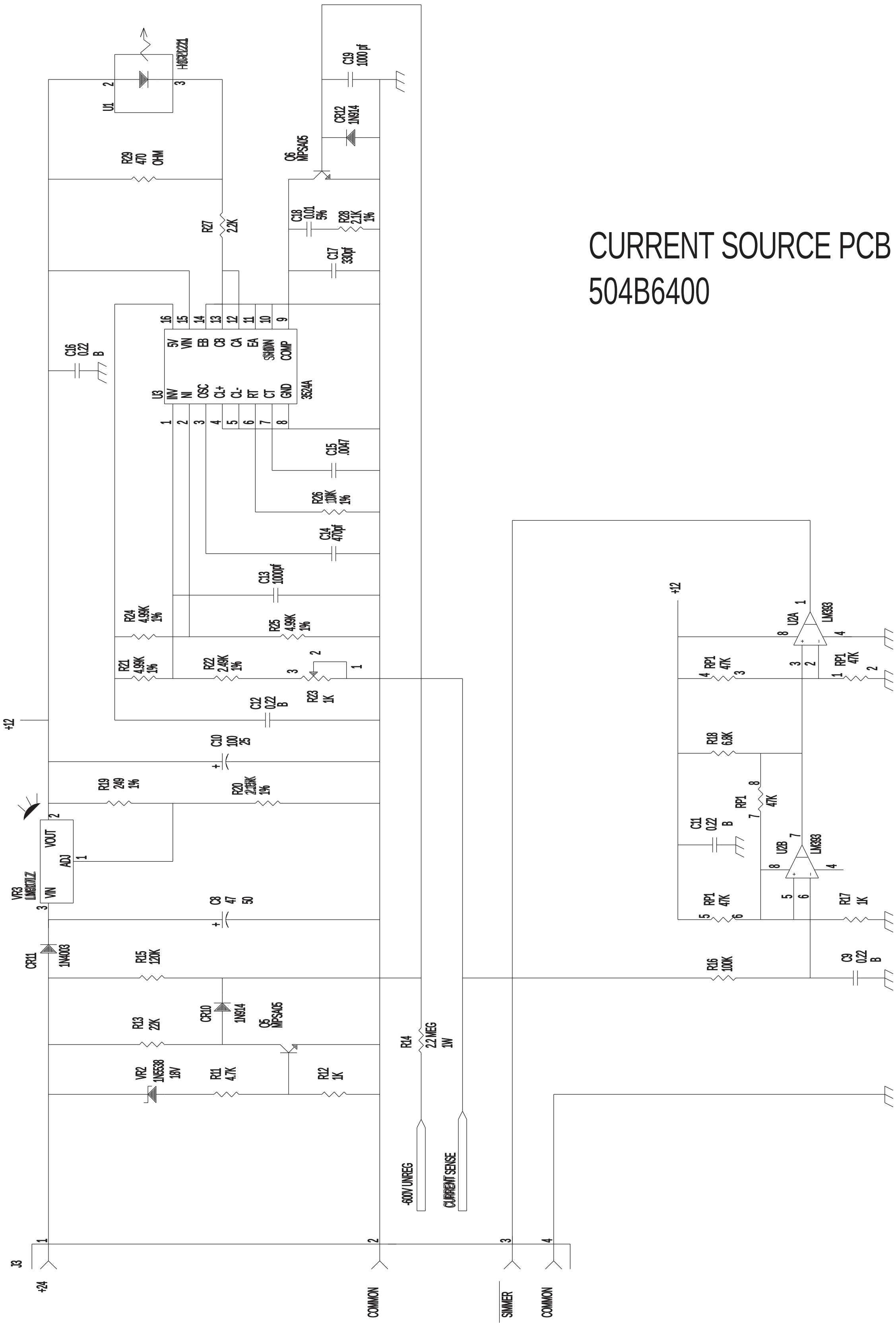


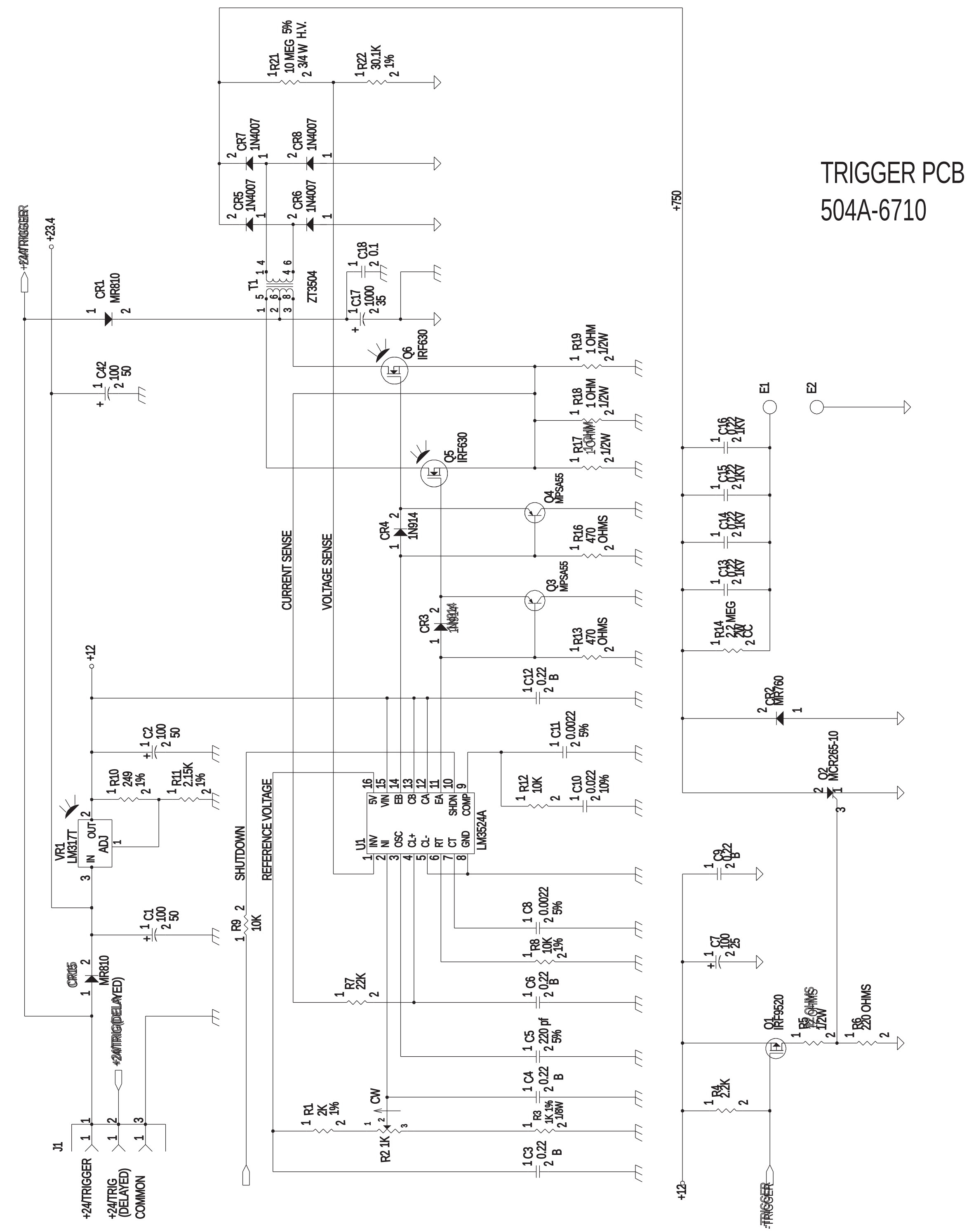
SCR PCB RUGGEDIZED

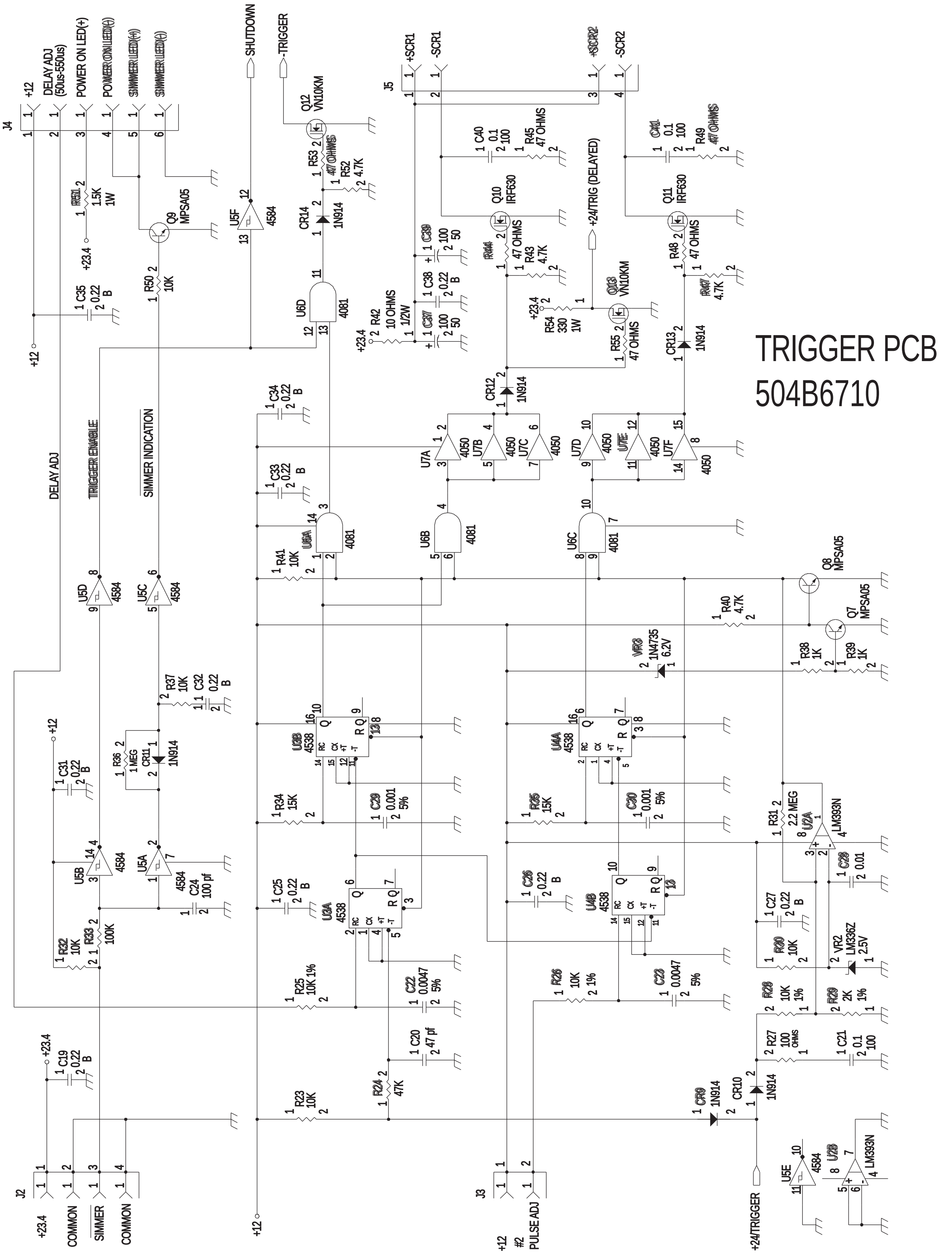
504-6600-2 Rev. E.

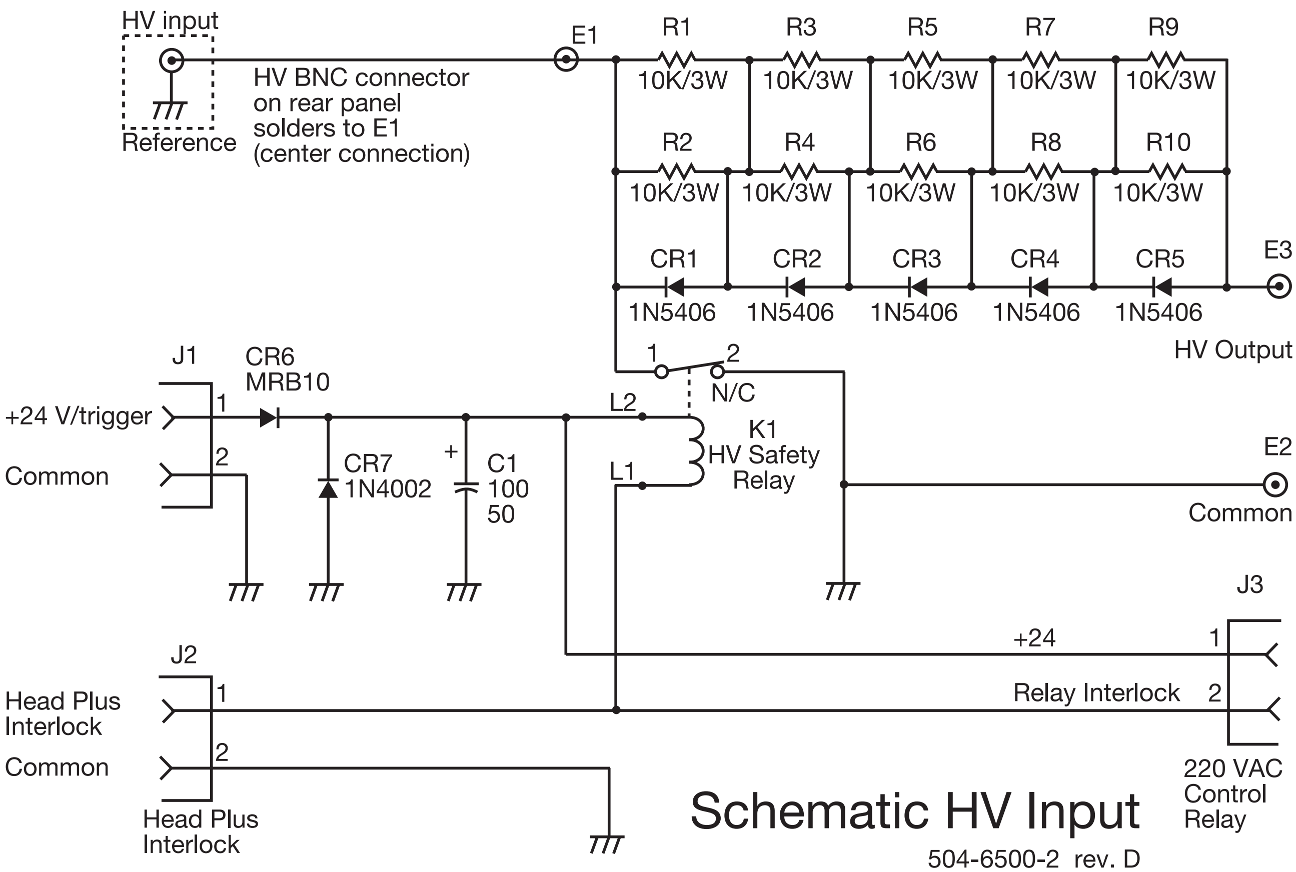

CURRENT SOURCE PCB
504A-6400-2
J2
COMMON
SIMMER (250ma-600ma)
-600V UNREG
CURRENT SENSE
R30 R31 R32 R33 R34 100K 1/2W
CR13 CR14 CR15 CR16 CR17 1N5406
C7 0.1 1000
CR8 1N4007
CR9 1N4007
CR7 1N4003
CR6 1N4003
CR13 1N4003
L1 70mh
R6 R7 R8 R9 R10 10 OHMS,1/2W,1%
Q4 BUZ50
Q3 BUZ50
CR5 3SFO
R4 47 OHM 1/2W
R5 47 OHM 1/2W
C6 0.1 1000
Q1 MPSA05
Q2 MPSA55
R3 10K
C5 0.22 B
U1 HCPL2211
C4 0.22 B
C3 22 35
R1 33K 5W
R2 33K 5W
VR1 1N4742 12V
C1 660 400
C2 400 660
RT1 CL-60
CR1 MUR760
CR2 MUR760
CR3 MUR760
CR4 MUR760
J1
220VAC 1□

CURRENT SOURCE PCB
504B6400

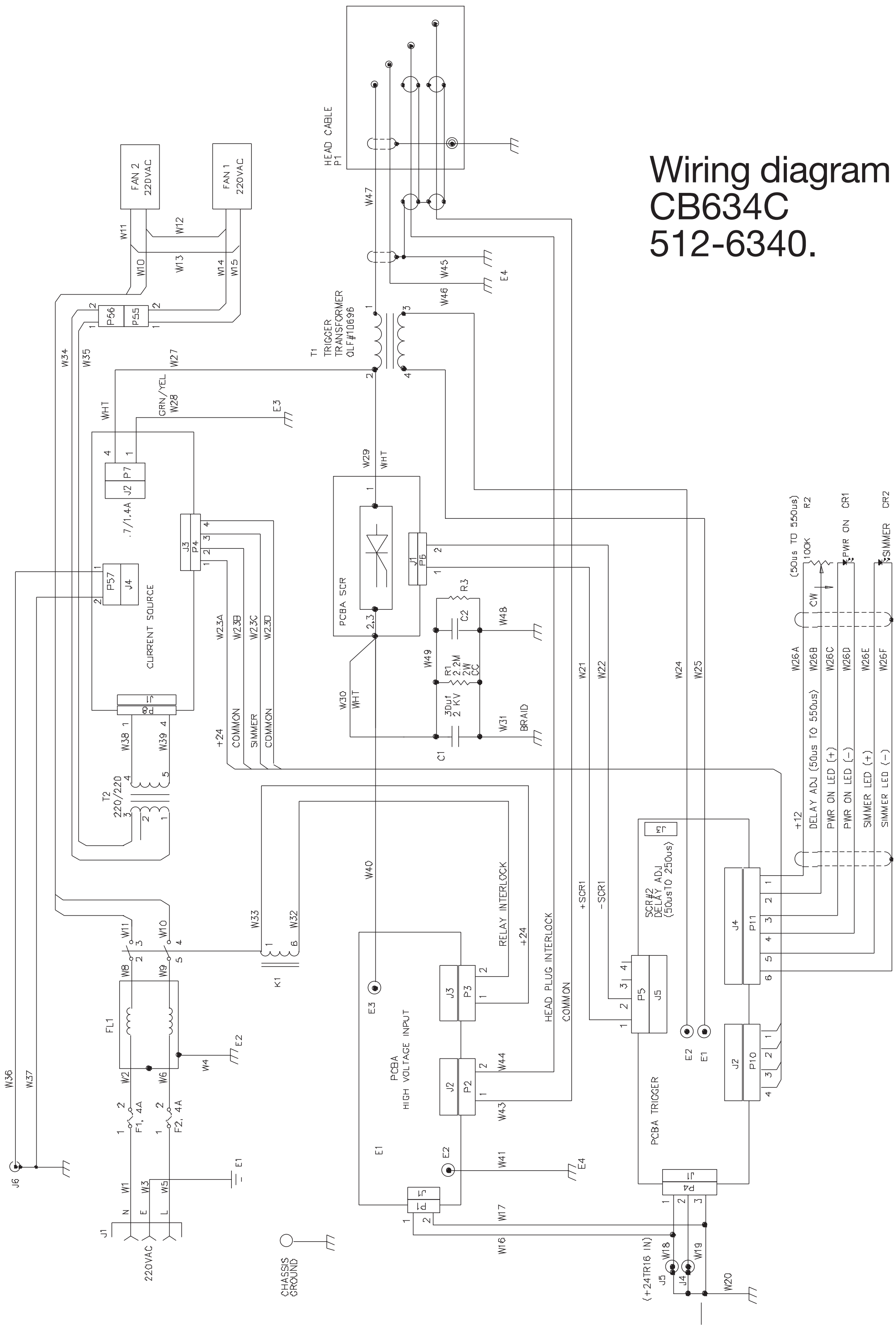


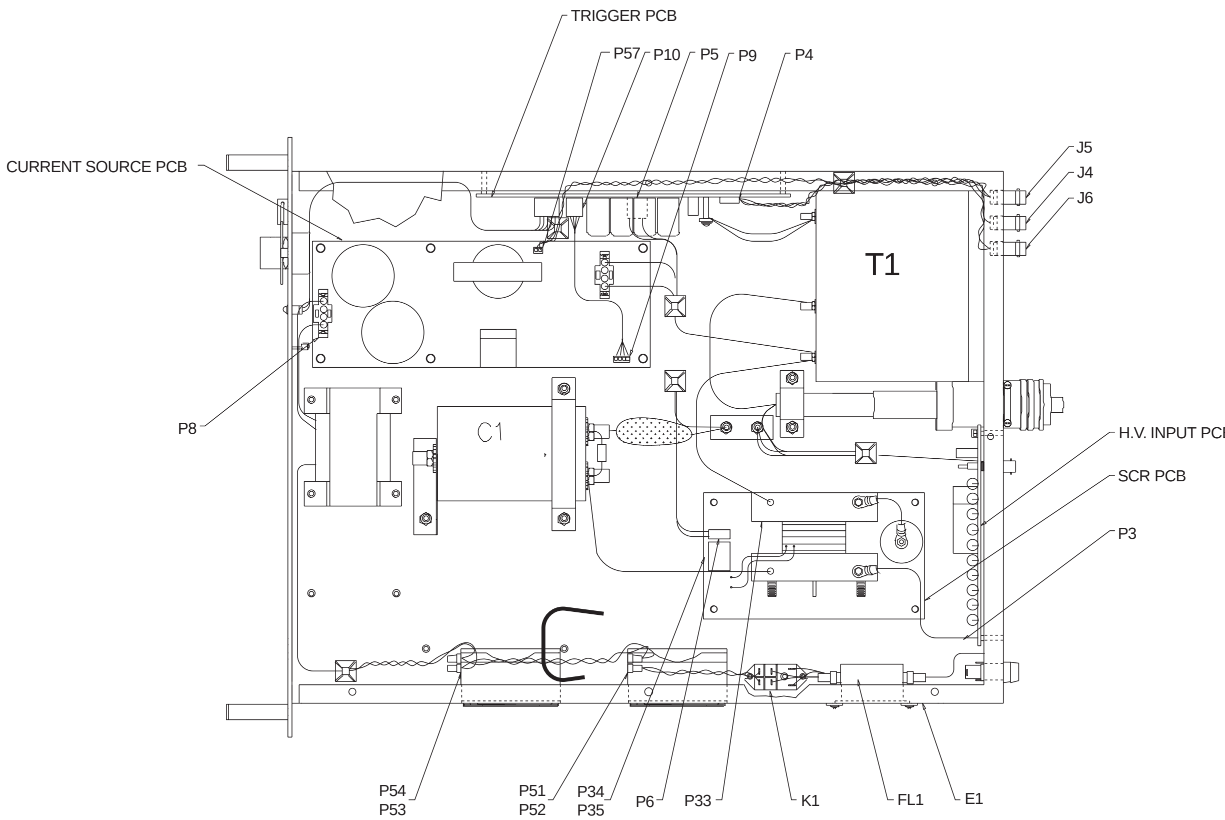

TRIGGER PCB
504A-6710

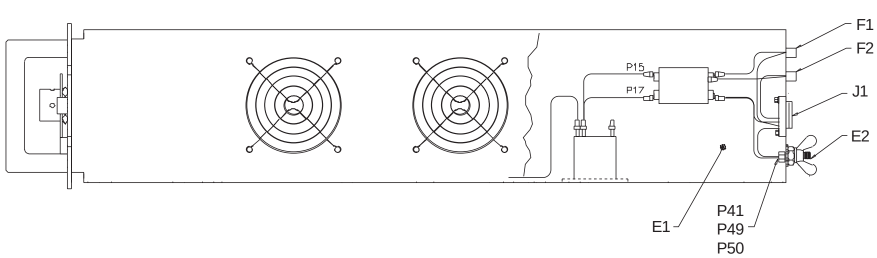

TRIGGER PCB
504B6710


HV input
Reference
HV BNC connector
on rear panel
solders to E1
(center connection)
E1
R1
R3
R5
R7
R9
10K/3W
10K/3W
10K/3W
10K/3W
10K/3W
R2
R4
R6
R8
R10
10K/3W
10K/3W
10K/3W
10K/3W
10K/3W
CR1
CR2
CR3
CR4
CR5
1N5406
1N5406
1N5406
1N5406
1N5406
E3
HV Output
J1
CR6
MRB10
+24 V/trigger
Common
1
2
CR7
1N4002
+
C1
100
50
L2
L1
1
2
N/C
K1
HV Safety
Relay
E2
Common
J3
+24
1
Relay Interlock
2
220 VAC
Control
Relay
J2
Head Plus
Interlock
Common
1
2
Head Plus
Interlock
Schematic HV Input
504-6500-2 rev. D

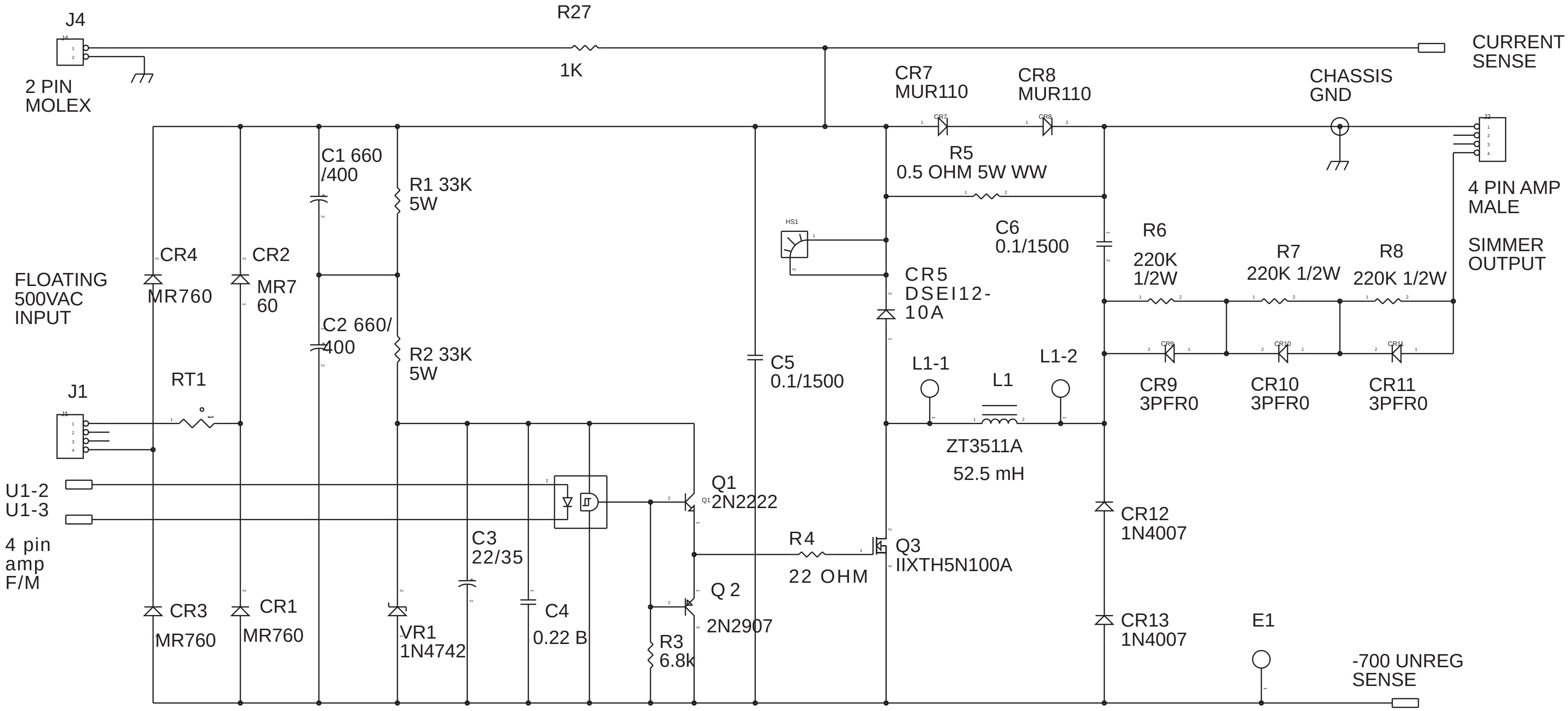
Wiring diagram CB634C 512-6340.







CB631C Chassis
512-6310



Current source
.7/1.4A PCB
505A9300-2
rev. J.

NOTES:

1. CAUTION--DANGEROUS VOLTAGES
2. 500 VAC INPUT MUST BE FROM FLOATING SOURCE ONLY.

Chapter III CG604C Cooling Group Contents

Chapter III   Subassemblies & Module Descriptions

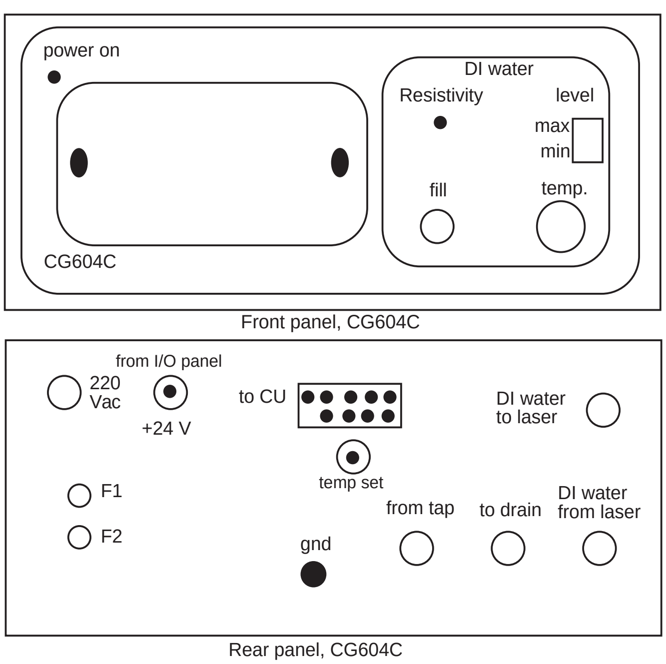
H. Cooling Group, CG604C

mini index

1. General Description

The CG604C cooling group is a rack mounted unit that is located in the bottom of the cabinet. The purpose of the CG604C is to cool the flashlamps and the rods in the laser heads. The heated water from the laser heads is then recirculated into the CG604C to be cooled again. The CG604C cools the heated water by having cold tap water running through a heat exchanger located next to the reservoir. It is a 3PGM @ 2PSIG water-to-water heat exchanger. The tap water temperature should not exceed 70°F (21°C) with the flow dependent on system loading (see graph, page 3-90).

The CG604C cooling group is a two way heat exchange system. It cools the laser head when the laser system is on, and heats the laser head when the system is off. When the laser system is off, the Pre-Heat Switch at the right rear of the laser cabinet chassis connects the cooling unit to the power line. The temperature control circuit will keep the laser system at 29.5°C or 35°C (9050 model only) which can begin lasing immediately after turning the laser system on.



CG604C front & rear panels.

2. Structural Organization

The DI (de-ionized) water exits the back side of the unit going through the centrifugal pump and then going directly to the laser heads. It returns from the laser heads and goes through the heat exchanger. There is a pick-off that takes a small portion of the DI water and runs it through the temperature regulator valve and then the DI cartridge before dumping it back into the reservoir. The rest returns directly to the reservoir.

The small opening in the top of the reservoir just behind the DI cartridge is for filling the reservoir with DI water.

Refer to the front panel drawing and the "Resistivity" light. This is set at 500 KΩ.cm. The light will be yellow at startup. After a warm-up period of 10-20 minutes this light will turn off when the water resistivity is good. If this light stays yellow after a reasonable warm-up period, then the DI cartridge needs to be replaced.

Also on the front panel is the **POWER ON** light, temperature gauge, fill/drain spout and a water level window.

There is a heater option which is used to decrease the warm-up time and is rated at ≈600 watts. The heater is independent of the security interlocks.

3. Principle of Operation

DI water is pumped from the reservoir through the laser heads. The water required for each round trip then flows out of the laser heads in series and then returns to the unit where it is cooled down again with tap water. The temperature regulator uses a proportional valve to keep the DI water at ±1°C. The cooling group has three security interlocks; a flow/pressure sensing switch, a DI temperature switch and a liquid level switch. The water pressure switch is set for 1GPM. These interlocks are connected with the other electronics subsystems in order to prevent damage in the event of cooling system failure.

Unit requirements:

a) A grounded AC source at 208-240 V, 1 phase

b) A 3 gallon supply of DI water

c) A tap water flow of 3-4 gal/min. at 40-60 PSI for the CG604C

d) A tap water temperature of <70°F (21°C).

4. Connections

a) **220 Vac** - plug in power cord from I/O panel in bottom of cabinet (see drawing p. 3-15)

b) **F1** & **F2** - fuses

c) **to CU** - receptacle for CU security cord

d) **GND** - grounding strap

e) **DI water to laser** - line from here takes chilled water to laser bench

f) **DI water from laser** - line from here carries heated water from bench and returns it for chilling

g) **from tap** - line is input for city water

h) **to drain** - line carries heated tap water to city drain.

5. Filling and Startup

Before turning on the unit for the first time, follow this procedure:

a) refer to front panel drawing and use fitting supplied. Attach $^3/_8$" dia. hose with funnel and fill through fitting marked **fill/drain**

b) fill reservoir with DI water

c) check all hose fittings for tightness. All external hose connections are to be made with $^1/_2$" ID tubing or its equivalent

d) Open door on front panel to be sure filter is in place

e) Turn on power with the circuit breaker on front of electronics cabinet. The green indicator light marked **POWER ON** on front panel should now be activated. Keep in mind that the warm-up period will vary depending on frequency of use. The longer the laser is not operating the longer the warm-up period will be.

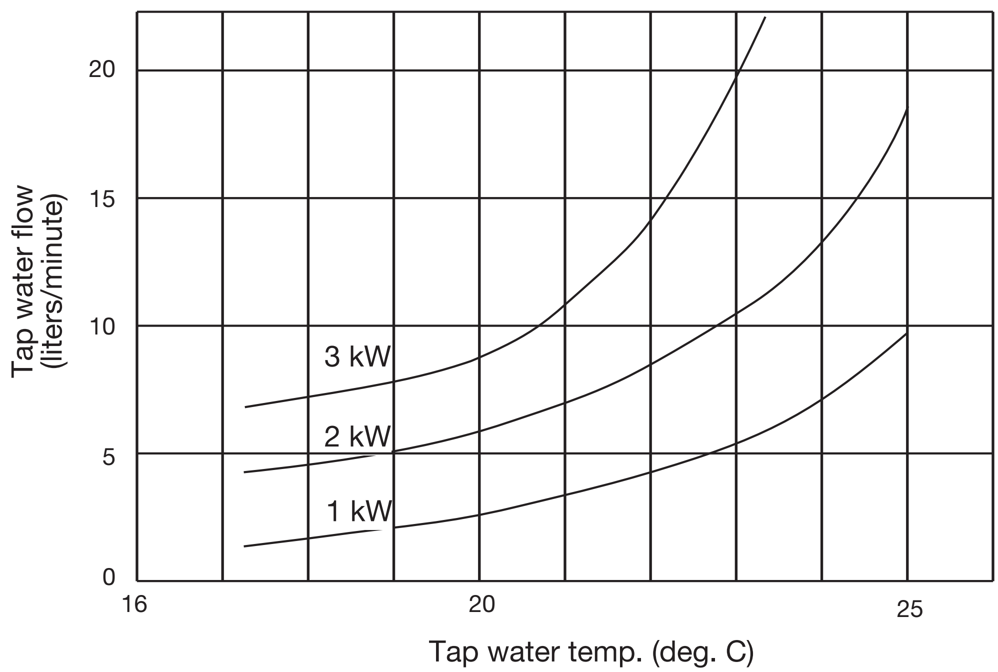
The following are set at the factory and should **NOT** be adjusted by user:

f) the heater thermostat

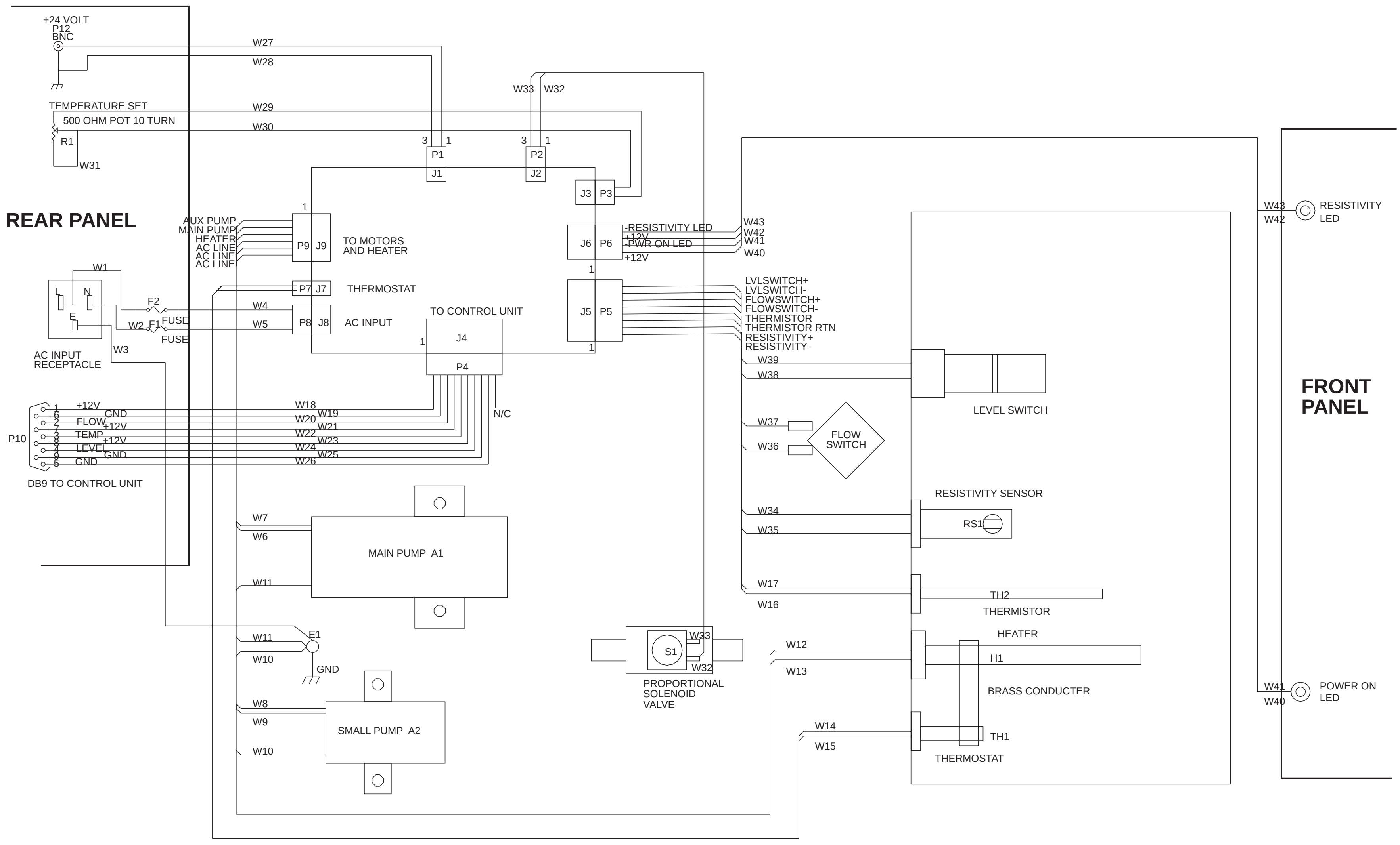
g) the operational temperature in the temperature regulator valve.

6. Maintenance

The recirculating cooling system of the cooling group requires a minimum of service. Normal checking of lines for tightness and leaks should be carried out monthly. The cooling unit has a built-in DI filter. The filter should be replaced every 6 months or when indicated by front panel resistivity light. Order replacement filters from Continuum part no. 313-0099. The cooling group should be checked once a year for loose connections, loose screws and fasteners. (See Maintenance section for instructions on changing the DI filter.) All service inquiries should be made to Continuum.

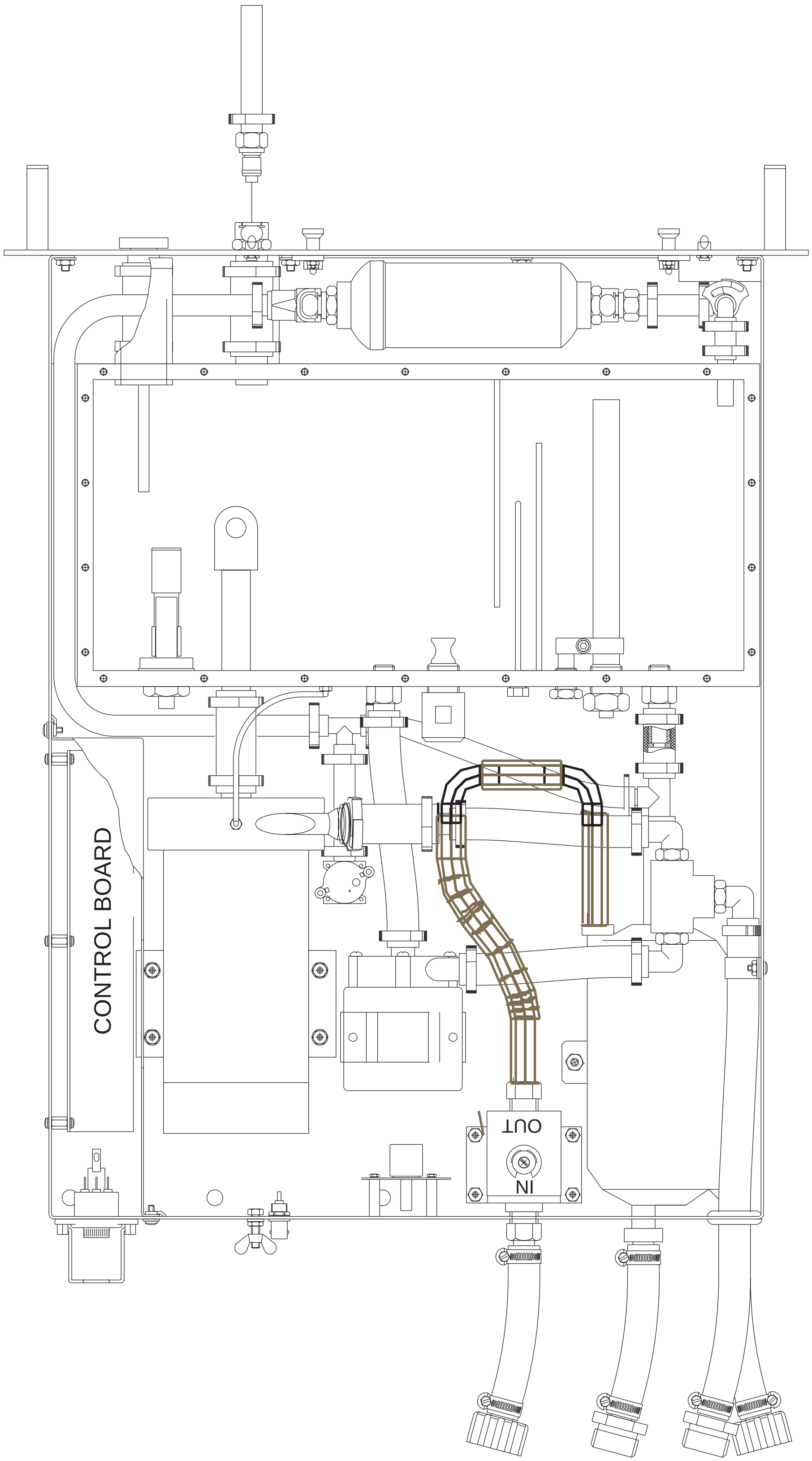


CG604C (10 & 30 Hz only) cooling requirements.

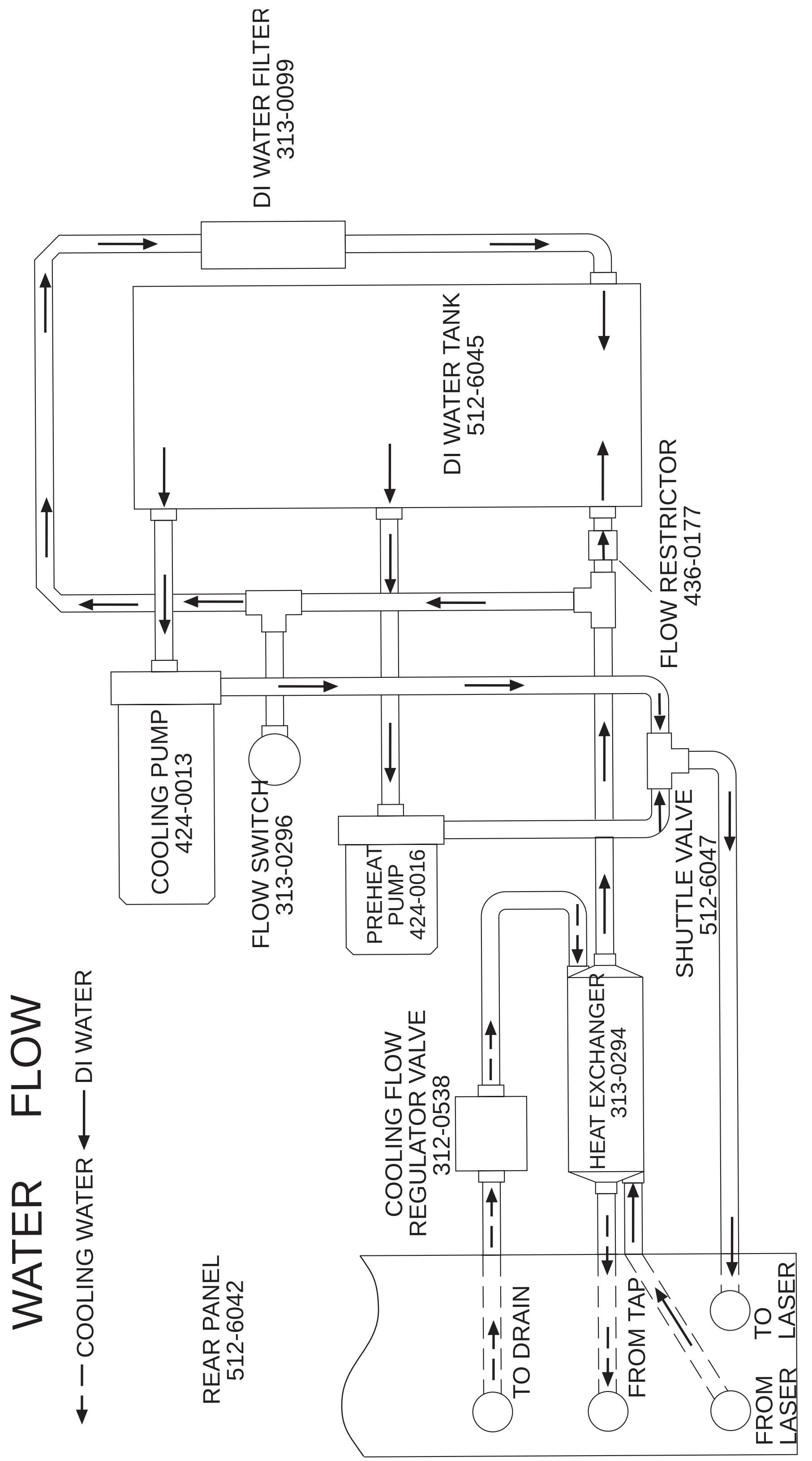


Wiring Diagram

Assy, CG604C
512-6040, sht. 8, rev. f

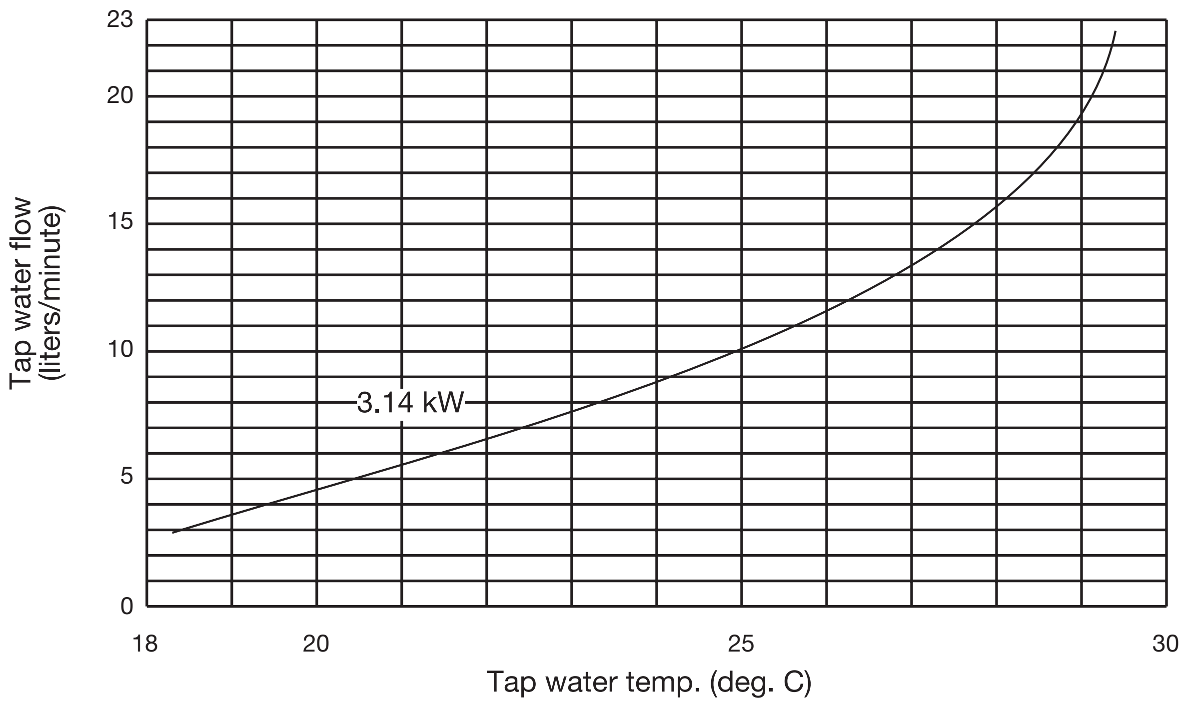


CG604C Assembly
512-6040, sht. 6



Water Flow Diagram

512-6040, sht. 7, rev. f



9050 Cooling Requirements

(35° C Regulating Temperature)

Chapter IV Maintenance Contents

System maintenance schedule.

	Each month	Every 6 months	Every 12 months
Check systen alignment see troubleshooting	X		
Clean/inspect optics see page 4-1	X		
Check for bacteria & perform cleaning procedure of DI water see page 4-8		X	
Change DI filter in cooling unit see page 4-7		X	
Replace flashlamps see page 4-2			X
Inspect cooling water loop connections		X	

Chapter IV Maintenance

The Precision II series requires minimal maintenance, however, there are some things that should be checked on a weekly basis.

Examine the optics biweekly and clean as inspection warrants. Initial cleaning can be done with pulsed air. Then, if streaks or dust persist, the optics should be carefully cleaned with soft optical tissue and either reagent grade methanol or isopropyl alcohol.

A. Cleaning optics

Equipment needed:

- reagent grade (or better) methanol
- lens tissues
- hemostat (surgical pliers)
- finger cots or surgical style gloves
- cotton swabs
- eyedropper

Unmounted optics

1) Always wash your hands first in order to remove all dirt and oil residues and put on finger cots or gloves.

2) Hold one sheet of lens tissue over optic to be cleaned.

3) Using eyedropper, place a few drops of good quality methanol on top of lens tissue.

4) Drag the lens tissue across the optic once only.

5) If a residue of solvent is left on the optic, repeat the procedure using less solvent and a new tissue until no residue remains.

Mounted optics and rods

1) Wrap lens tissue on a cotton tipped applicator.

CAUTION:

When cleaning glued optics use solvent sparingly. Excessive solvent will dissolve the glue and your cleaning action may drag the residue onto mirror surface.

2) Apply a few drops directly on lens tissue and shake off excess.

3) Swab optic gently with the applicator starting at center and working towards the edge.

4) Repeat step 1, using a dry swab to remove residue.

B. Flashlamp removal & replacement

Precision II series heads

Head	Laser	Head P/N	Flashlamp Qty.	Flashlamp P/N
811U-05	Precision II 9000	507-1700	1	203-0019 (50 Hz)
811U-06	Precision II 8000 & 9000	507-0700	1	203-0019 (10, 20, 30, 50 Hz)
811U-07	Precision II 8000	507-1000	1	203-0035 (10 & 20 Hz)
811D-09	Precision II 9000	507-0770	1 1	203-0036 (10, 20, 30 Hz) or 203-0032 (50 Hz)
811U-09	Precision II 9000	507-0750	1 1	203-0036 (10, 20, 30 Hz) or 203-0032 (50 Hz)
812V-09	Precision II 8000	507-0900	2	203-0032 (10, 20 Hz)
812V-12	Precision II 9000	507-0970	2	203-0032

Lamp replacement

Equipment needed:

- new flashlamp (see above)
- exploded head drawings, pages 3-3 to 5
- distilled water
- 2.5mm Allen wrench
- lens tissue
- cotton swabs

1) Study exploded head drawing.

2) Turn off main breaker located on the front right hand side of electronics cabinet.

3) Disconnect head plug cables at rear of laser bench (large green military style connectors). Label each cable for correct reconnection.

4) Disconnect the thermal switch at the white plastic connector.

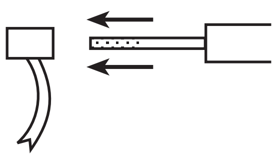
CAUTION

Base cradle screw threads are aluminum and can be stripped if over tightened. A snug fit is adequate.

5) Release the laser head from its base cradle plate by screwing clockwise (viewed from above) the thumbwheel located below the laser head.

CAUTION

Turn off the night-time water pump by flipping the switch on the rear panel of the power supply.



6) Use your fingers to gently pull off the lamp connectors from the lamp electrodes.

7) Remove the laser head from the bench and place it on a solid, flat work area.

8) Use a 2.5 mm Allen wrench to remove the Allen bolts holding the white plastic lamp holders at each end of the laser head.

9) With a cotton swab wet each end of the exposed flashlamp electrode, and then gently remove the white plastic lamp holders.

10) Press firmly on either flashlamp electrode and pull on the other electrode to remove the lamp. See exploded head drawings, pages 3-3 to 5.

11) Clean new lamp with lens tissue and methanol before installation. Note anode/cathode orientation of new lamp and insert lamp into head according to “+” and “-” stickers on side of head.

12) Slide the new lamp into the laser head and install the Teflon backing ring and then the black "O"ring over the ends of the lamp electrodes. Note: wet all parts before reinsertion.

13) Wet the exposed electrode and then replace the white plastic lamp holders. A firm slowly rotating motion is best.

14) Once the lamp retainers have been slipped over the lamp electrodes, check to make sure the lamp is centered in the head and then bolt the lamp retainers in place.

15) Place laser head near base cradle and reattach lamp connectors at each end. Make sure lamp electrodes are dry before sliding lamp connectors over lamp ends.

16) Place the laser head in base cradle and begin to screw the thumb wheel counter clock wise to reattach the laser head to its cradle. Gently rock the laser head as you tighten the thumbwheel.

17) Reattach the thermal switch at the white plastic connector.

18) Flow test the laser head. If the lamps leak, repeat the procedure from step 7. If the laser head leaks from around the cradle, repeat the procedure from step 15.

19) Log the date and the shot count from the RB601 and the procedure is complete.

C. Rod replacement

Equipment needed:

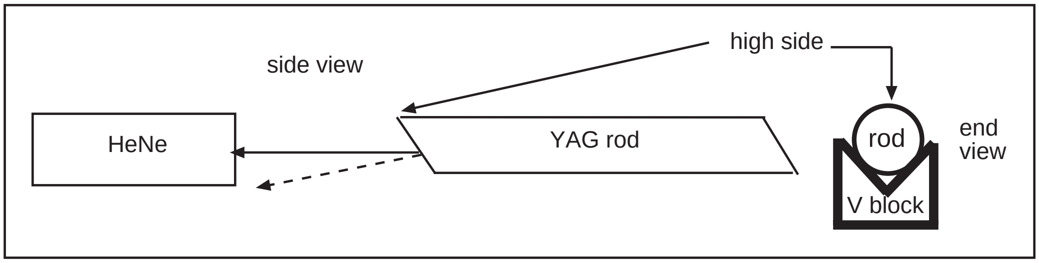
- Replacement rod
- Exploded head drawings, pages 3-3 to 5
- HeNe laser
- New rod “O”rings
- “V” block
- 2.5mm Allen wrench
- Lens tissue
- Cotton swabs
- Distilled water
- Finger cots

1) Study exploded head drawing.

2) The YAG rod is a parallelogram cut at a 2° angle.

- hold rod vertically at eye level and slowly rotate. Note the “high side”
- on a optical bench position a HeNe laser beam parallel to the bench and at “V” block beam height
- lay rod horizontally in “V” block and position so that HeNe passes through rod
- rotate rod so that HeNe reflection off rod face is reflected downward to its lowest position
- using a pencil, mark 12 o’clock position of rod as the “high” side.

3) Turn off laser. Main breaker located on the front right hand side of electronics cabinet should be in the off position.



CAUTION

Turn off the night-time water pump by flipping the switch on the rear panel of the power supply.

4) Disconnect head plug cables at rear of laser bench (large green military style connectors). Label each cable for correct reconnection.

5) Disconnect the thermal switch at the white plastic connector.

6) Release the laser head from its base cradle plate by screwing clockwise (viewed from above) the thumb wheel located below the laser head.

7) Use your fingers to gently pull off the lamp connectors from the lamp electrodes.

8) Remove the laser head from the bench and place it on a solid, flat work area.

9) Use a 2.5 mm Allen wrench to remove the Allen bolts holding the white plastic lamp holders at each end of the laser head.

10) With a cotton swab wet each end of the exposed flashlamp electrode, and then gently remove the white plastic lamp holders.

11) Press firmly on either flashlamp electrode and pull on the other end to remove the lamp. Wrap the lamp in lens paper and place to the side.

CAUTION:

When both endplates have been removed, the rod may be loose and could fall out if the head is tipped.

12) Mark the endplates of the laser head so that the anode and cathode endplates are not mixed.

13) Using a 2.5 mm Allen wrench remove the four screws at each end holding the endplates.

14) Grasp firmly the central body housing in one hand and the endplate in the other and slowly slide the endplate directly away from the central body. Exercise caution so that no shear force is placed on the YAG rod. Repeat the procedure on the other side.

15) Put on gloves or finger cots and grasp the rod at one end, while at the other you gently roll the rod "O"ring off the end of the rod. If the "O"ring is old it may be necessary to use a dental pick to pull off the rod.

NOTE:

Do not touch rod ends with bare fingers.

16) Now still grasping the rod gently pull it through the head central body and out the other end. Wrap rod with lens tissue and put aside.

17) Inspect central body cladding for any damage.

18) Take replacement rod and place new "O"ring on marked end.

19) See chart below for orientation of rod and then gently insert rod end with no "O"ring into and through central body cladding.

Head	**View**	**Position of high side mark**
811U-05	from rear mirror of osc.	9 o'clock
811U-06	from rear mirror of osc.	9 o'clock
811-07	from rear mirror of osc.	9 o'clock 8000
811U-09	from rear mirror of osc.	3 o'clock (1st head) 9000
811D-09	from rear mirror of osc.	9 o'clock (2nd head) 9000
812V-09	from rear mirror of osc.	3 o'clock 8000

20) Place rod "O" ring of other end of rod. Again check rod orientation and clean rod ends.

21) Replace the endplates on the laser head, tightening the screws in an X pattern to compress "O"ring evenly.

22) Check the anode cathode orientation of lamp and insert the lamp into head according to"+" and "-" stickers on side of head. The cathode (-) has a hemispherical shape and the anode (+) has a flat surface and the red dot.

23) Install the Teflon backing ring and then the black "O"ring over the ends of the lamp electrodes. Note: wet all parts before reinsertion.

24) Wet the exposed electrode and then replace the white plastic lamp holders. A firm, slow rotating motion is best.

25) Once the lamp holders have been slipped over the lamp electrodes, bolt them in place.

26) Place laser head near base cradle and attach lamp connectors at each end.

27) Place the laser head in base cradle and begin to screw the thumb wheel counter clock wise to reattach the laser head to its cradle. Gently rock the laser head as you tighten the thumbwheel.

28) Reattach the thermal switch at the white plastic connector.

29) Flow test the laser head. If leaks occur, repeat the necessary procedures.

30) Log the date and the shot count from the control unit and the procedure is complete.

D. Replacing the DI water filter

Equipment needed:

- new DI filter (P/N #313-0099)
- 3 gallons distilled water (12 liters)
- drain pan
- 8" adjustable wrench
- roll of teflon tape
- Phillips screwdriver

The DI filter should be changed every six months or when indicated by the resistivity light on the front panel.

1) Review the overhead drawing for the CG604C (see page 3-81).

2) Remove the four Phillips head screws that hold the unit in the electronics rack and pull the CG604C unit forward ~ 4 inches. The large fill plug on top of the reservoir should be exposed.

3) Drain the CG604C reservoir by using the quick connect suppled with the system. Plug the quick connect into the **FILL** located on the front panel and drain the old water into a drain pan.

4) Remove the cartridge access panel by grasping the two plate knobs and pulling directly away from front panel.

5) Note flow direction indicated by arrow on replacement DI filter and on unit still in CG.

6) The DI filter is held in place by quick-connects at each end. The quick-connect can be released by pressing down on the metal tab and pulling directly away from the filter.

7) Once the old DI filter is removed use a wrench to unscrew the quick-connects left in each end. Remove old teflon tape from the threads.

8) Put new teflon tape around the threads of the quick-connects and install them into the new filter observing the correct flow pattern.

9) Install the new DI filter by plugging the male/female quick-connects into their counter parts. Flow should be right to left.

10) Add with new distilled water. The **FILL** connector on front panel can be used or add it through fill plug on top of reservoir. Fill to **MAX** level indicated on front panel of CG.

Caution

Leave enough volume in the reservoir for the water in the heads. When the heads are removed, the water will back drain into the reservoir and overflow if kept too full.

11) Turn on CG and check for leaks. After ~ 1 minute of run time again check reservoir level and add water if below **MIN** level.

12) Replace cartridge access panel, slide unit back into rack, bolt into place and procedure is complete.

Bacterial growth

To inhibit the growth of bacteria in the DI water of the CG604C, we strongly recommend that the following procedure be done once every 6 months regardless of how many hours the system has been run.

Equipment needed:

- Hydrogen peroxide, 3%, 750-1000 mL (can be purchased at a local drug store)
- DI filter, Continuum P/N 313-0099 (optional)
- Funnel

Note:

The laser system can be running during this procedure.

1) Remove the DI filter from the CG604C chassis.
2) Remove the threaded cap from the DI tank cover.
3) Check the water level in the tank and drain as much water as is needed from the tank to prevent overflow. Now pour the hydrogen peroxide into the tank.
4) Allow the laser to run without the DI filter for approximately one day with flashing. Drain the reservoir and fill it with DI water and run for one hour before draining the reservoir again. Now pour in fresh DI water and insert a new DI filter.

NOTE:

Monitor the “quick disconnects” to the DI filter to assure no water leakage is occurring. The resistivity light will go red once the peroxide is poured into the tank and will remain that way for several hours after the DI filter is installed.

E. “O”ring replacement

Equipment needed:

- Exploded head drawings, pages 3-4 & 5
- New rod “O”rings
- 2.5 mm Allen wrench
- Lens tissue
- Cotton swab
- Distilled water
- Finger cots

1) Study exploded head drawing.

2) Turn off main breaker located on the front right hand side of electronics cabinet.

CAUTION

Turn off the night-time water pump by flipping the switch on the rear panel of the power supply.

3) Disconnect head plug cables at rear of laser bench (large green military style connectors). Label each cable for correct reconnection.

4) Disconnect the thermal switch at the white plastic connector.

5) Release the laser head from its' base cradle plate by screwing clockwise (viewed from above) the thumbwheel located below the laser head.

6) Use your fingers to gently pull off the lamp connectors from the lamp electrodes.

7) Remove the laser head from the bench and place it on a solid, flat work area.

8) Use a 2.5 mm Allen wrench to remove the Allen bolts holding the white plastic lamp holders at each end of the laser head.

9) With a cotton swab wet each end of the exposed flashlamp electrode, and then gently remove the white plastic lamp holders.

10) Press firmly on either flashlamp electrode and pull on the other electrode to remove the lamp. Rap the lamp in lens paper and place to the side.

11) Select either end of the laser head and using a 2.5 mm Allen wrench remove the four screws holding that one rod endplate. Remember only loosen one endplate.

12) Grasp firmly the central body housing in one hand and the loosened endplate in the other and slowly slide the endplate directly away from the central body. Exercise caution so that no shear force is placed on the YAG rod.

13) The rod "O"ring should now be visible. Use a blunt soft probe (end of cotton swab) to help slide the "O"ring off the end of the rod.

14) Don gloves or finger cots and carefully using your fingers slide a new rod "O"ring over the end of the rod.

15) Use Methanol,lens paper and cotton swabs and clean rod end.

16) Replace the endplate on the laser head, tightening the screws in an X pattern to compress "O"ring evenly.

17) Repeat steps 11-16 for the other end of laser head. Remember at all times the rod should be firmly held in position by either on endplate or the other.

18) Replace flashlamp "O"rings.

19) Note anode cathode orientation of lamp and insert lamp into head according to "+" and "-" stickers on side of head.

20) Install the Teflon backing ring and then the black "O"ring over the ends of the lamp electrodes. **Note:** Wet all parts before reinsertion.

21) Wet the exposed electrode and then replace the white plastic lamp holders. A firm slowly rotating motion is best.

22) Once the lamp holders have been slipped over the lamp electrodes bolt them in place.

23) Place laser head near base cradle and attach lamp connectors at each end.

24) Place the laser head in base cradle and begin to screw the thumbwheel counter clock wise to reattach the laser head to its' cradle. Gently rock the laser head as you tighten the thumbwheel.

CAUTION:

Ensure rod orientation is still correct. If not, refer to rod replacement procedures.

NOTE:

Base cradle screw threads are aluminum and can be stripped if over tightened. A snug fit is adequate.

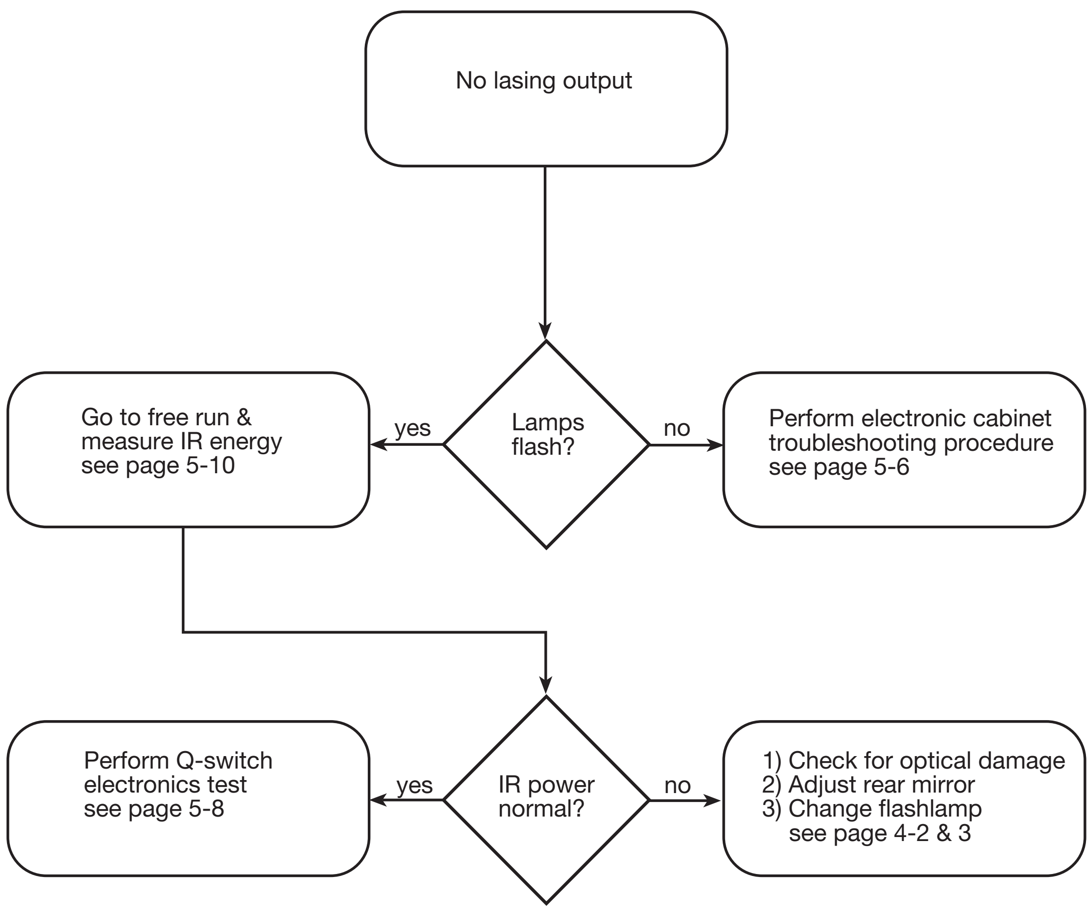
25) Reattach the thermal switch at the white plastic connector.

26) Flow test the laser head. If leaks occur, repeat the necessary procedures.

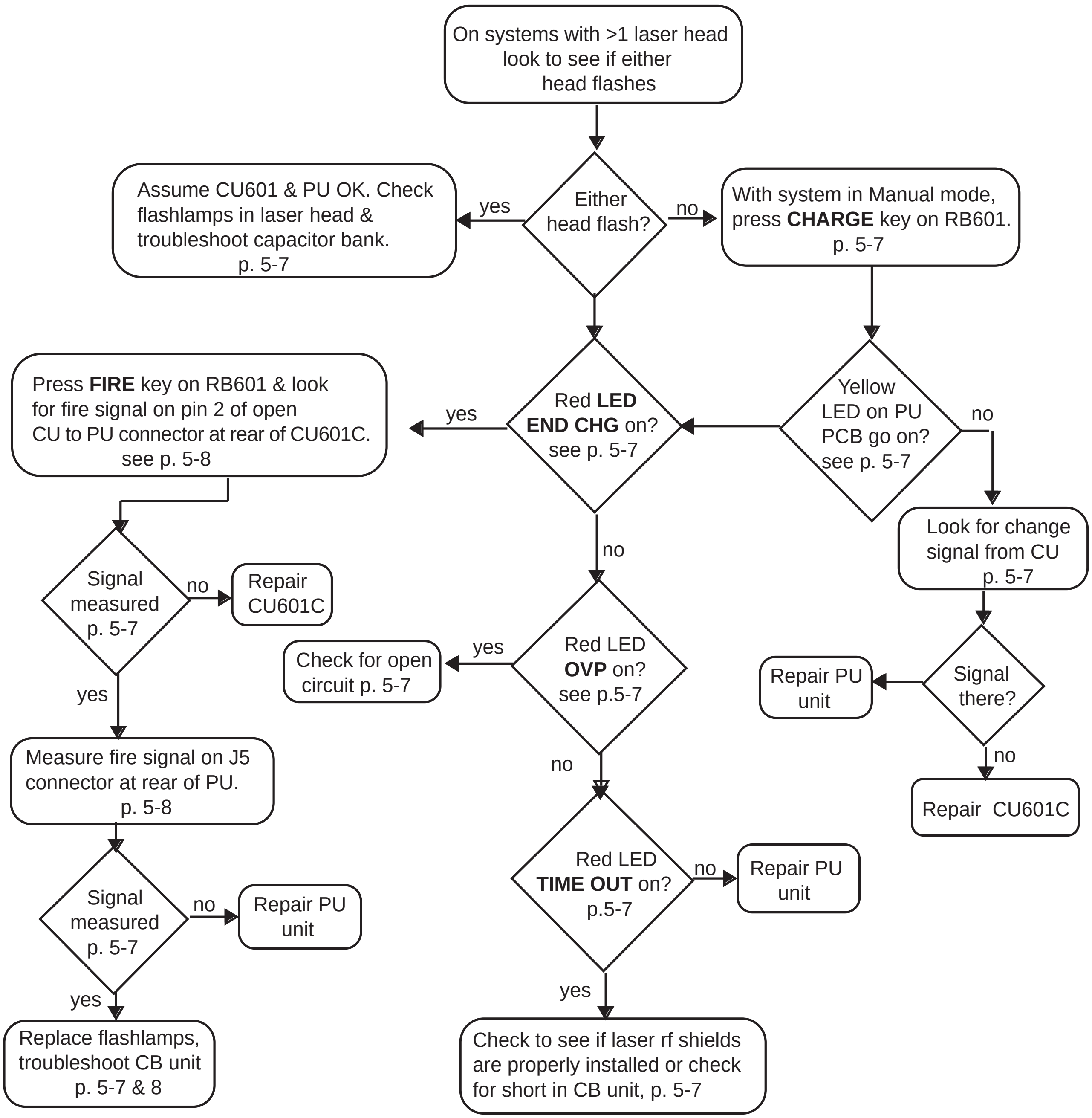
27) Log the date and the shot count from the control unit and the procedure is complete.

Chapter V Troubleshooting Contents

Troubleshooting guide for Precision series



Electronics rack troubleshooting flow chart.



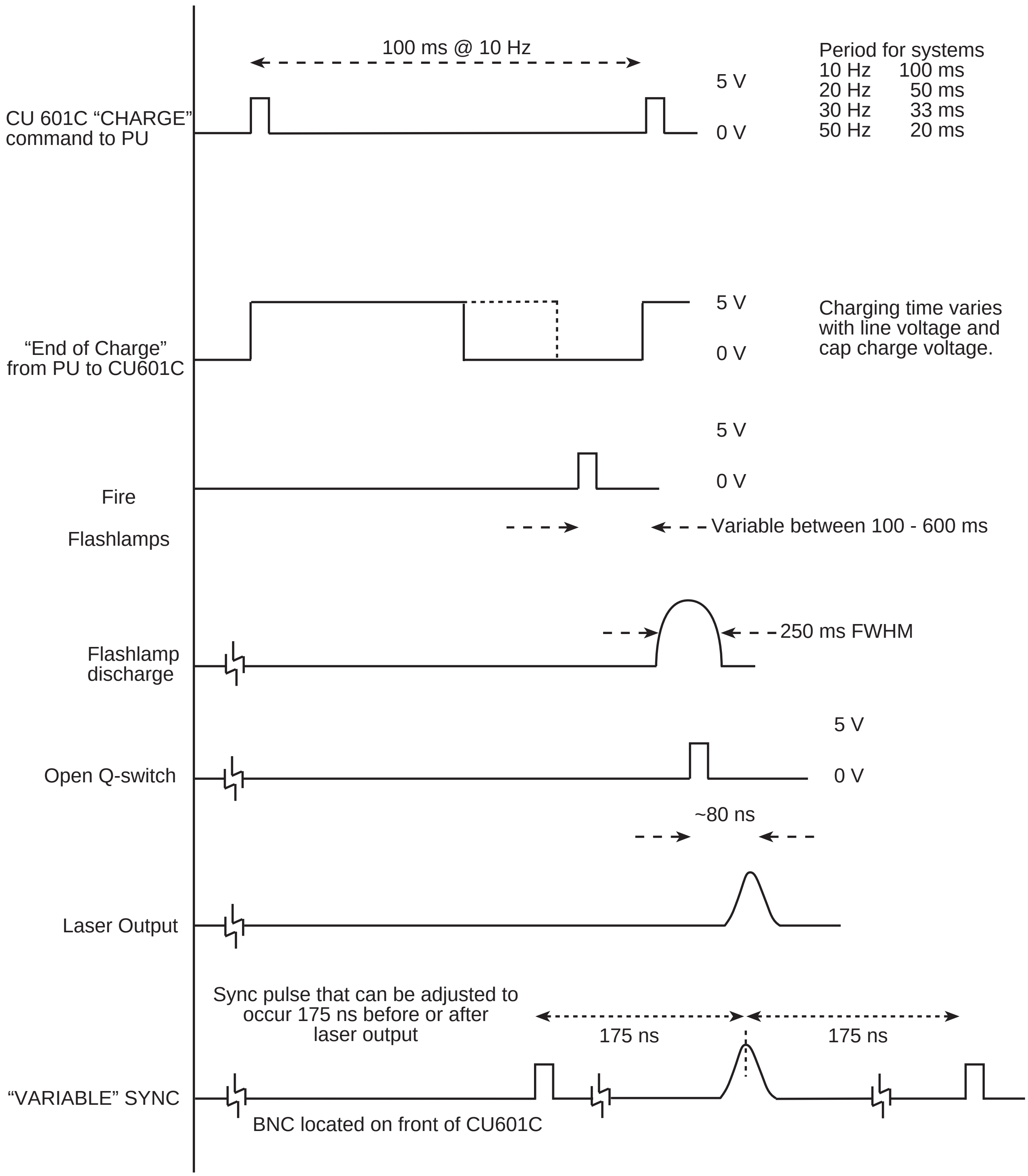
Optical troubleshooting chart.

Problem	Proposed Action	Reference
Low Harmonics Energy	check for damaged optics check crystal angle & optimize check 1.06µm energy check low energy osc. check low energy amp. check seeder & optimize	make list of damaged optics & contact Continuum page 5-20 page 5-12 page 5-20 Appendix, page 7-3
Low Energy Amplifier	check for damaged optics check osc. energy check amp. alignment & realign replace flashlamps perform electronic troubleshoot see low energy amp.	make list of damaged optics & contact Continuum page 5-14 page 5-20 page 4-2 page 5-6 page 5-20
Low Energy Oscillator	check osc. alignment & realign check for damaged optics replace flashlamps see low energy osc.	page 5-13 make list of damaged optics & contact Continuum page 4-2 page 5-12
No Lasing	check lasing in free-running mode perform electronic troubleshoot	page 5-10 page 5-6

Optical troubleshooting chart cont'd.

Problem	Proposed Action	Reference
Poor Harmonic Beam Quality	check tuning angle of crystal & optimize check 1.06µm beam quality check for damaged optics	 page 5-12 make list of damaged optics & contact Continuum
Poor Beam Quality	check osc. alignment & realign check amp. alignment & realign check for damaged optics check for free-running	page 5-12 page 5-20 make list of damaged optics & contact Continuum page 5-10
Poor shot-to-shot stability	check for free-running check seeder & optimize check for damaged optics replace flashlamps check osc. stability in free-running check cooling group for slime & clean perform electronic troubleshoot	page 5-10 seeder manual in Appendix make list of damaged optics & contact Continuum page 4-2 page 5-15 page 5-24
No seeder output	check for "power on" & allow for warmup check that seeder shutters are open	contact Continuum

Precision II series chronograph.



Chapter V Troubleshooting

A. Electronics rack troubleshooting

This procedure is designed to allow the user to troubleshoot down to the module level (CU, PU, CB). It does not allow for troubleshooting down to the individual component level (IC, transistor, etc.) within a rack module.

Equipment needed:

Volt Ohm Meter (VOM)
Oscilloscope
Standard scope probe
Phillips screwdriver
10 kΩ $^{1}/_{4}$ watt resistor

NOTE:

In order to perform the following test you must be able to observe LED's (light emitting diodes) located on the power unit logic board. To open the power unit:

a. With rack main breaker off disconnect all cables at rear of PU.

b. Remove the power unit from the rack and take off its lid. The logic board is located in the front left corner of the PU drawer body.

c. Put the unit back into rack with lid off and protruding ~8 inches from rack so that the logic LED's can be observed.

d. Reconnect all cables at rear of power unit and turn on main breaker.

1) Reset system logic - turn off and then turn back on the button switch on front of CU601C.

2) Confirm that green LED **VOLT OK ENABLE** is on. Look at center of PU logic board. If it is not lit:

- on rear of CU601C are 4 CU to PU "D" type connectors. At an open CU to PU connector measure with a VOM the dc voltage on pin #5. It should be 15V if the RB601 indicates no security faults.
- if 15 V is measured, repair PU
- if 15 V is not measured, repair CU.

3) Confirm yellow LED **CHG ORDER** is on. With RB601 in manual mode press the **CHARGE** button. Look at center of PU logic board. The yellow LED labeled **CHG ORDER** should be on. If not:

- Look at rear of CU601C and locate the four CU to PU "D" type connectors. At an open CU to PU connector plug a10 kΩ resistor between pins #6 and #4. With an oscilloscope look on pin #4 for a 15 to 0 Vdc signal each time you press the RB601 **CHARGE** button.

4) Confirm red LED **END CHG** is on. With RB601 in manual mode press the **CHARGE** button. Look at center of PU logic board. The red LED labeled **CHG ORDER** should be on. If not:

- Does red LED labeled **OVP** come on? If it does, this indicates that the unit is charging into an open circuit.

  a. Look for breaks in HV cables between power unit and capacitor bank.

  b. Check for 24 Vdc on J5 connector on back of CB.

  c. Check that head plug cable from CB to laser bench is properly connected.

- Does red LED labeled **TIME OUT** come on? It indicates that the unit is charging into a dead short. Suggest replacement of main storage capacitor in CB. Suggest checking the following:

  a. Check that head plug cable from CB to laser bench is properly connected.

  b. Look for a short circuit inside capacitor bank unit.

5) Look for CU **FIRE** signal. On rear of CU601C are 4 CU to PU "D" type connectors. At an open CU to PU connector plug a 10 kΩ resistor between pins #6 and #2. With an oscilloscope look on pin #2 for a 15 to 0 Vdc signal each time you press the RB601 **FIRE** button. If no signal is present, repair CU601C.

6) Look for PU **FIRE** signal - On rear of PU use BNC "T" to measure the signal going from PU J5 to CB J5. The signal should go from 24 to 0Vdc each time the RB601 **FIRE** button is pressed. If the signal is there:

a. replace lamps in laser head

b. repair suspect CB

If signal is not present, repair PU.

B. Q-switch troubleshooting

The following is an electrical test procedure that allows for determination of defective Q-switching electrical elements. Those elements are:

- CU601C
- Marx board
- 750 power board.

Equipment needed:

- oscilloscope
- standard scope probe
- DVM
- long (~15') BNC
- BNC "T"
- pot "tweaker"

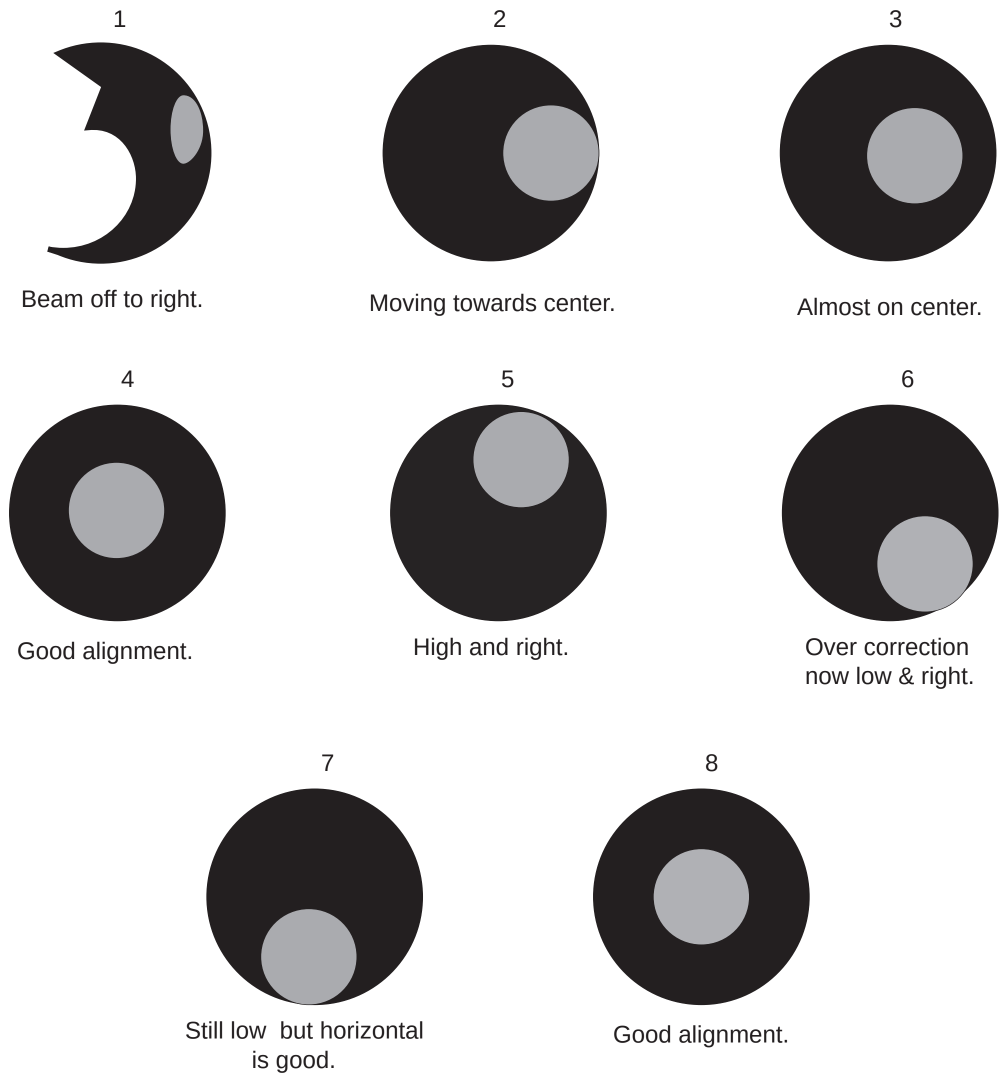
1) External trigger your scope on the 24 Vdc to 0V signal coming from the "J4" BNC connector (use BNC "T") located on back of oscillator capacitor bank. This 24 V to 0V signal occurs at start of flashlamp firing.

2) On your oscilloscope set the following:

Termination - 1 MΩ
Time base - 100 μs/div
Vertical amp - 5 V/div
Trig - external and negative going.
Scope trace should be placed near top of screen.

3) Place the standard scope probe between the two connector pins extending from the top of the Pockels cell. The probe should lean against the two contact pins but ***MUST***

Burn pattern diagram.



All of the burn patterns shown above are simulated "back burns".
Orientation: Taken between mirror mounts 2 and 3 as though the beam is coming out of the page.

1. Beam is well off to the right. It is so far out of alignment that the dark circle does not look complete. Make adjustment to the horizontal axis to move to the left.
2. Looks better but still needs more left adjustment.
3. Almost on the center. Needs more left adjustment.
4. The alignment looks good.
5. This beam is high and to the right. Bring down the vertical first.
6. Moved the vertical too far down. Adjust horizontal to the left.
7. Horizontal now looks good, but the vertical needs to move up.
8. Beam now looks good.

Actual "burn" patterns may look slightly different, but, the procedure is the same.

NOT make direct electrical contact. The 4 kV signal is inductively coupled onto the scope probe so close proximity is all that is required.

4) On the RB601 select PGM-3 mode and press **ACTIVATE** and **Q-SWITCH ON/OFF**. The shutter should remain closed and the Shutter LED should be off.

5) You should see on the scope a negative going pulse several volts in amplitude occurring ~200 µs after scope trace start.

6) If the trace is there but the timing is not ~200 µs adjust Q-switch delay on RB601.

7) The presence of the trace indicates the three main electrical components are all working properly and the system should Q-switch. If there is no trace proceed to step 8.

8) Measure +15 V square wave 10µs wide pulse that comes from the CU601C to the Marx board to trigger the avalanche action. With scope still externally triggered and PGM-3 still activated, unplug the small SMB connector and measure signal on female center. If there is no signal, perform continuity tests between SMB connector and the CU601C. If OK, repair control unit.

9) With the system in the **MANUAL** mode, measure the 750 Vdc generated by the PC board located under the laser bench. To do this, first power down the rack. Next disconnect the male HV BNC connector at bench surface. Power up the rack and using a DVM measure the voltage on the center female pin. It should read ~750 Vdc; if not, adjust the voltage by using a pot "tweaker" to access the adjust pot through hole in top of laser bench. If there is no voltage replace the board.

10) If the 750 Vdc and the trigger pulse are there and still no pulse is visible when you perform steps 1-5, then the conclusion is that the Marx board has failed and it needs to be replaced. Attempts to actively test the Marx board are very difficult and are not recommended.

C. Going to free-running

The purpose of this section is to provide a detailed description on setting up the oscillator to run in the free-running mode. It is important to follow the procedures carefully. Any deviation from the listed procedures could cause extreme optical damage.

Equipment needed:

- 1 oscilloscope (1MΩ input)
- 1 photodiode risetime ~1ns
- 1 Styrofoam high density beam block
- 1 metric Allen wrench set
- 1 English Allen wrench set

1) Turn system off.

2) Locate $\lambda/4$ plate #1 (closest to Pockels cell) and using a pencil, mark the holder ring at the 12:00 position. This will show the initial position of $\lambda/4$ plate.

3) Loosen set screw holding the $\lambda/4$ plate #1 and rotate it approximately 45° in either direction.

WARNING!

*Ensure that Q-switch is **OFF** and green LED on remote box (RB601) is **OFF** during free-running operation.*

4) Turn system on, open shutter but do not activate the Q-switch. The system will now lase with a long pulse output.

Re-closing the cavity

1) Turn off the system.

2) Rotate $\lambda/4$ plate #1 back to its original position (pencil mark at 12:00). Tighten set screw.

3) Turn on system, open shutter, but leave Q-switch off.

4) To check for free-running, use an IR card, an oscilloscope or look for green light after the SHG crystal.

5) If free-running is observed tweak on rotational position of $\lambda/4$ plate #1.

6) If no free-running is observed, gradually increase oscillator pump voltage on the power unit by 100 V while continuing to monitor for free-running. If observed, repeat step 5.

7) Return oscillator pump voltage to normal operational level. There should now be a 100 V buffer between this point and where the system free-runs.

8) Continue normal system operation.

D. Oscillator alignment optimization

This section will describe specific procedures for aligning and optimizing oscillator performance.

Equipment needed:

- Kodak Linagraph paper (type 1895, CAT#1986108)
- clear plastic bags
- 1 metric Allen wrench set
- Mirror mount adjustment tool
- Styrofoam high density beam block
- Photodiode (~1 ns risetime)
- Fast oscilloscope, >350 MHz with 50 Ω inputs (seed lasers only)

When the Linagraph (or "burn paper") is new it will have a pink emulsion on one side of it. Expose this side to room light for approximately 30-40 minutes to turn the emulsion to a light brown color. Once it's this color the paper will give the best representation of the laser beam profile.

The back surface of the paper is the one that does not have the emulsion on it. When taking shots (or "burns") into this side of the paper it is called a "back" burn. Since the emulsion is very sensitive to the laser energy it tends to saturate easily. By taking burns through the back of the paper the energy is attenuated slightly, making interpretation of the burn pattern easier.

CAUTION:

The output coupler (6) should ***NEVER*** *be adjusted. Misalignment of this optic may necessitate a system realignment by a factory engineer.*

1) Allow the system to warm up to its normal operating temperature. Activate PGM-1 for ~30 minutes.

2) Take a piece of burn paper (approximately a 3" x 5" strip) and place it in a plastic bag.

3) Place the paper between the oscillator output coupler (6) and the first turning mirror (7c) (see diagram, page 5-21).

4) Position the paper so that its back surface is facing the output of the oscillator (6).

5) On RB601 activate PGM -2, press on **SHUTTER** and **Q-SWITCH** keys.

6) Press the **FIRE** button. The laser will now output a single pulse.

7) Close the intracavity shutter by depressing the **SHUTTER** button.

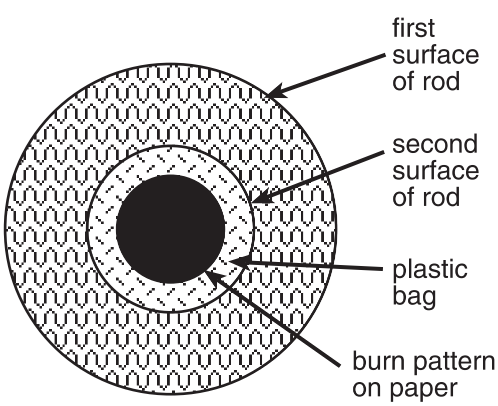
8) Remove the “burn” paper from the bag and examine the pattern.

NOTE:

Remember the orientation of the paper when the “burn” is taken. This will make it easier to determine which axis of the mirror mount to adjust.

The burn pattern should be a dark circle roughly the same diameter as the oscillator rod (see page 5-23). Inside of this circle there should be another circle that is smaller and a light brown color. The light brown indicates higher energy in that area.

Image as seen through rod.



9) Adjust the “rear” mirror (1) for optimum burn pattern and maximum energy. Example: If the light brown circle is in the lower half of the dark circle then the beam needs to come up. This would require a vertical adjustment.

Note: The mirror has both vertical and horizontal adjustment. The vertical adjustment is the stainless steel threaded post that is on the upper left corner of the mount (when viewing the mount from the back). The horizontal adjustment is on the lower right corner.

10) Repeat previous steps until the light brown circle is centered.

NOTE:

If after following this procedure the output beam does not look similar to the initial installation burn patterns then a more complex realignment may be required. Contact Continuum Service Department for information.

11) Check down stream alignment of optics, amplifiers and crystals to insure that they are still correctly aligned.

12) Log service and date and resume normal operation.

E. Oscillator optimization (with an oscilloscope)

For the Precision series lasers that employ the “Gaussian” oscillator, optimizing cavity alignment using an oscilloscope can be very useful.

If the oscillator is well aligned the output pulse width is at its narrowest (5-8 ns). The converse is also true. When the cavity is misaligned the pulse width will broaden. Therefore monitoring the pulse width while making oscillator adjustments will allow you to achieve optimum cavity alignment.

Equipment needed:

- Burn paper
- clear plastic bags
- high density Styrofoam beam dump
- Photodiode with ~1 ns risetime
- BNC cable
- >350 MHz oscilloscope with enhanced view screen

The following is a procedure for optimizing the oscillator by monitoring the pulsewidth:

NOTE:

This procedure should be done in conjunction with the alignment procedure described previously in this section.

1) Turn on the flashlamps and let the system warm up ~20 min.

2) Place the beam block in the beam path after the first turning mirror 7c.

3) Set up the oscilloscope:

a. Plug in photodiode to 50 Ω termination.

b. Run a trigger BNC cable from the “Seeder Trigger” BNC (located on the side of the laser bench) to the time base of the scope.

c. Set the triggering of the scope to trigger off the +15 sync pulse.

d. Adjust the time base to view a 5-10 ns pulse. The trigger pulse will occur ~90 ns before lasing.

e. Place the photodiode on the laser bench so that it will be able pick up the laser light scattered off the beam block.

Be sure that the voltage setting on the power unit is set to the laser's normal operating voltage.

4) Activate PGM-3 and press **SHUTTER** and **Q-SWITCH** buttons.

5) While viewing the pulsewidth on the scope adjust the vertical position of the back mirror M#1. Make very small adjustments at first to be able to determine effect of the adjustment.
When making adjustments to the back mirror the pulse will change in size (pulsewidth) as well as move in time. Generally, when adjusting the mirror in the correct direction the pulse will move to the left indicating reduced build-up time.

6) Optimize the vertical position.

7) Now repeat the process while adjusting the horizontal axis.

8) Once the alignment is optimized activate PGM-2 and take single shot burns to verify oscillator alignment.

NOTE:

A very small adjustment on the back mirror can have an effect on the pulsewidth though it may not be noticeable on the burn paper.

F. Measuring oscillator stability in the free-running mode

The purpose of this section is to describe the procedure for measuring the shot-to-shot stability of the oscillator when it is in the free-running mode. These procedures should be used in conjunction with free-running found on page 5-10.

Equipment needed:

- 1 oscilloscope (1 MΩ input) fast scope not required
- 1 photodiode risetime of ~1 ns
- 1 Styrofoam high density beam block
- 1 metric Allen wrench set
- 1 English Allen wrench set

1) Use the procedure on how to go to free-running to set up the oscillator in the free running mode.

2) Check that the oscillator pump voltage is at its normal operating level.

3) Verify that the beam block is still in place between 7c and 7d and that the intracavity shutter is closed (see 5-21).

4) Re-check the oscilloscope settings:

termination - 1MΩ
vertical amp. - ~ 200mv/div.
time base - ~ 100 microsec
normal trig. and negative slope.

5) Open the intracavity shutter.

6) Adjust the photodiode position so that the vertical trace on the oscilloscope is equal to approximately 6 divisions at 200mv/div.

NOTE:

Make sure that the photodiode does not pick up excessive amounts of flashlamp light. With the intracavity shutter closed the flashlamp signal should be less than 1 division.

7) Use the vertical position knob on the oscilloscope to move the base line of the trace to the small 0% line. (This is for oscilloscopes that have a percent scale on the screen.)

NOTE:

The percent markers are common on most types of oscilloscopes. Generally it has small dotted lines to indicate the 0% and the 100% points. From the 100% line to the first small division mark is equal to 2%. From the 100% line to the next division mark is equal to 6%. Finally, from the 100% line to the first major division line is equal 10%.

8) Use the variable voltage input knob to set the peak of the lasing trace to the 100% mark on the oscilloscope screen.

9) Monitor the oscilloscope trace and measure the highest peak of the trace and the lowest peak. Take the percentage from the 100% line to both the high and low measurement and divide by 2. This will be the ± shot-to-shot stability of the oscillator.

10) A plus or minus shot-to-shot stability of between 1% and 2.5% is normal. If stability is poor, refer to troubleshooting guide.

G. Eliminating free-running

Free-running is a term used to describe the phenomenon of a Q-switched oscillator actually lasing before the Q-switch is open. This effect can be extremely damaging to all of the optics within the laser system because of the very high peak powers generated.

Equipment needed:

- 1 oscilloscope (1 MΩ input) fast scope not required
- 1 photodiode risetime of ~1 ns
- 1 Styrofoam high density beam block
- 1 metric Allen wrench set
- 1 English Allen wrench set

There are generally three ways in which free-running can occur:

- Misalignment: If the polarization optics, especially the $\lambda/4$ plate and the Pockels cell, become misaligned then the polarization within the cavity becomes slightly undefined. This means that the dielectric polarizer does not receive linearly polarized light. Therefore, when the polarizer is supposed to be rejecting energy out of the cavity, a certain amount “leaks” through. That “leakage” energy then builds up and becomes lasing. Since this lasing occurs before the Q-switch is opened, it is called free-running.

- Increased pump: If the flashlamp voltage is increased the oscillator will reach a level at which, due to the increased gain, it begins to lase. This once again occurs because the polarization optics cannot reject enough energy out of the cavity.

- Optical feedback: Optical feedback from amplifiers, or any reflective surface, can increase the amount of energy in the oscillator cavity. This increased energy, just as with turning up the pump voltage, can exceed the polarization optics ability to reject enough energy out of the cavity.

The list above are all examples of “passive” free-running. It is considered passive because the Q-switch is **OFF** when it occurs.

Free-running can also occur, especially in higher repetition rate systems (30 Hz and higher), when the Q-switch is **ON** (or opening). This is called “active” free-running. Active free-running is generally caused by thermal blooming effects in the Pockels cell.

Warning!

Operating the Q-switch while the laser is free-running can cause severe damage.

During normal laser operation free-running will manifest itself in the form of erratic shot-to-shot stability or even a snapping sound coming from the laser. If this occurs, stop the Q-switching immediately and follow the next procedure to eliminate the problem.

The following is a procedure to check for and eliminate free-running:

All optical adjustments should be made in the passive (not Q-switched) mode.

1) Place a beam block after the first turning mirror (7c) to block the oscillator beam.

2) Place a photodiode so that light scattered off of the beam block can be monitored.

3) Set up an oscilloscope (does not have to be a fast scope).

   a. Connect photodiode to a 1MΩ input on the scope.

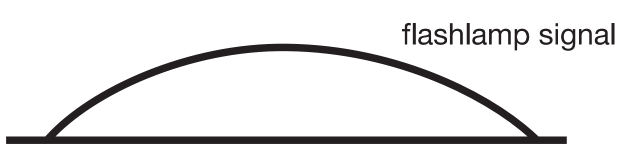
   b. Run a trigger BNC from J4 connector (located on the back of CB chassis) to the external trigger input on the scope.

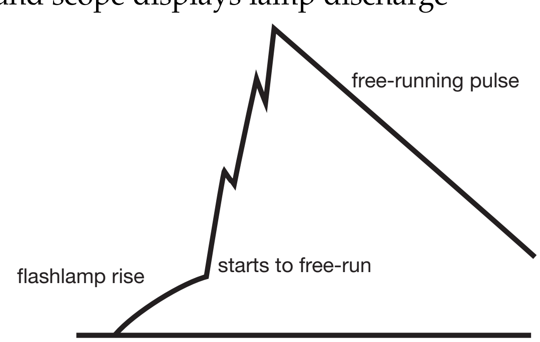
   c. Set the time base to 100 μs.

4) Ensure that the power unit is set to the normal operating voltage.

5) Start the laser (flashlamps firing only).

6) Adjust the photodiode so that it detects a small amount of the flashlamp light and scope displays lamp discharge curve.





7) Now press the **SHUTTER** button, located on the RB601, to open the intracavity shutter.

8) Check the scope display for any change in the waveform. When the shutter is opened, the flashlamp signal (on the scope display) should increase slightly.

9) If the wave form starts with a gentle slope then abruptly increases to a jagged peak, the laser is free-running.

10) If the laser is not free-running at this time, go to step 16.

To eliminate the free-running, adjustments to the polarization optics need to be made.

11) At this time make a small adjustment to the vertical axis of the Pockels cell through the vertical adjustment access hole located at the top of the Pockels cell mount.

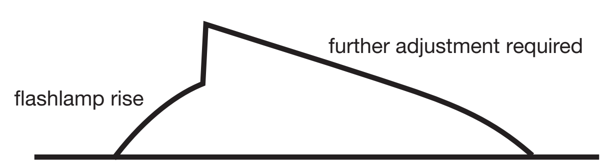
12) Note the vertical size of the scope display. If the trace becomes smaller, then the adjustment was made in the correct direction.

13) Continue to adjust the vertical axis until the amplitude of the trace is as small as possible or until the free-running stops.

If the free-running stops, then go on to step 15.

14) Now follow the same procedure as in steps 12 and 13 only this time adjust the horizontal axis located on the lower corner of the Pockels cell mount.

15) Continue these adjustments until the free-running has been eliminated.



16) Close the intracavity shutter and increase the pump voltage by 100 volts.

CAUTION:

Do not exceed 1.7kV unless otherwise instructed to do so by a Continuum representative.

17) Open the intracavity shutter and look at the oscilloscope to see if the laser is free-running.

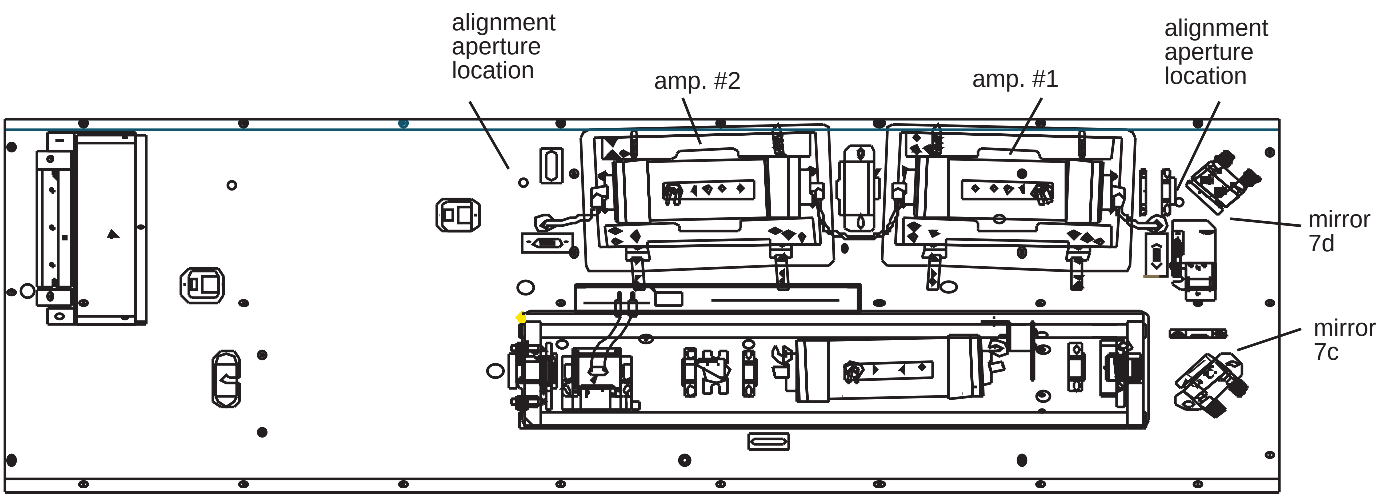
18) If the laser is in a free-running state, then repeat steps 11 through 15 while at this higher pump voltage.

Once the oscillator optics are properly adjusted, passive free-running should not occur until the pump voltage has exceeded 100 volts above the normal operating level. In many cases this voltage " buffer" will be even greater than 100 volts.

19) Once the "buffer" voltage is greater than 100 volts return the pump voltage to its normal level.

CAUTION:

After completing the free-running test procedure, it is very important to check the oscillator alignment once again. Any movement of the Pockels cell may cause a misalignment, requiring a rear mirror adjustment (1).

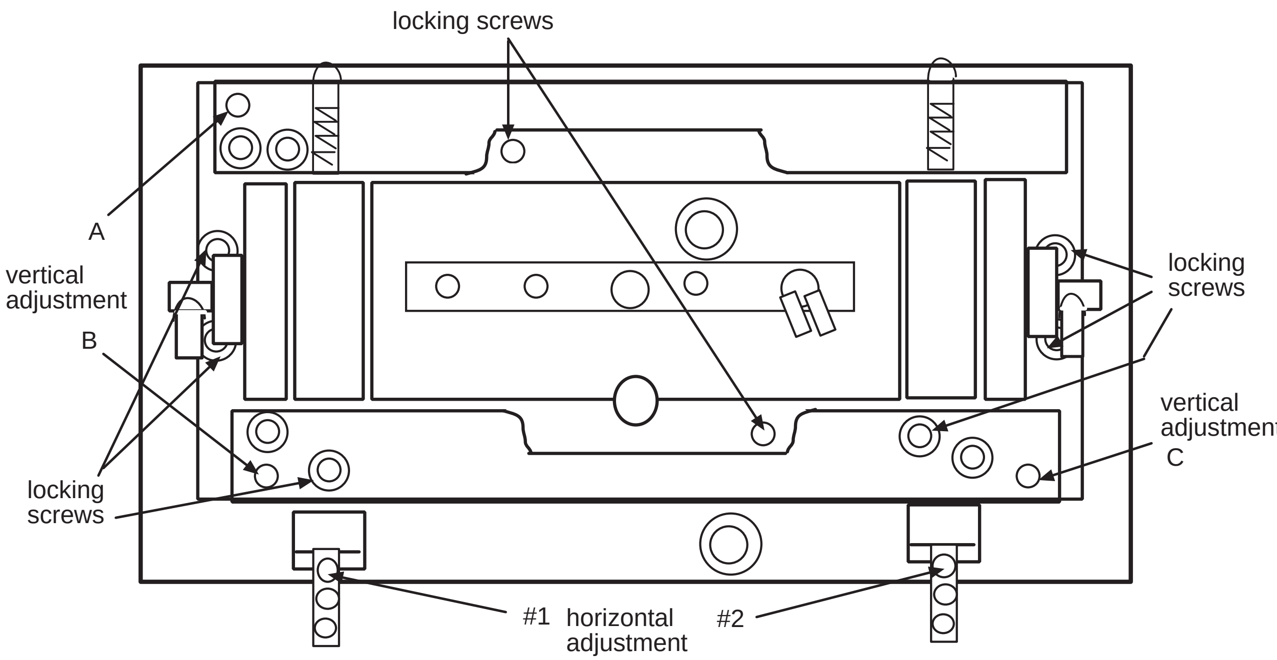


Alignment aperture positions.

H. Dual inline amplifier alignment single rod head, 811U-09

Equipment needed:

- burn paper
- clear plastic bags
- 1 metric Allen wrench set
- 1 Phillips screwdriver
- high density Styrofoam beam dump



Precision II amplifier adjustment screws.

The alignment of the Precision II 9000 series is the same for all repetition rates. This procedure assumes that the operator already knows how to align an oscillator.

Both amplifier heads in the Precision II 9000 are vertically and horizontally adjustable. They should be HeNe aligned first followed by the oscillator alignment to fit the pair of amplifiers. This is better than trying to align each one separately.

1) Remove both heads, quartz rotator mount, apertures and waveplate from the laser bench.

2) Place two alignment fixtures (pinholes set at 43 mm with a dowel pin on the bottom, P/N 998-0002), one after the second amplifier and the other near the wave plate mount location (see Alignment aperture positions, page 5-20).

3) Starting from the harmonics end of the bench, align the HeNe through the two pinholes.

4) Loosen all nine locking screws on each base plate.

5) Set the height from the top of the black anodized sole plate to the top of the gray base plate to 19 mm using the three vertical adjustment screws.

6) Using the horizontal adjustment screws, set the distance from the edge of the base plate opposite the adjustment screws to the edge of the bench cutout to 6 mm.

7) Replace the second amplifier head.

8) With the horizontal adjustment screws, align the rod so that it is centered on the HeNe beam. To translate the head use both screws. For angular adjustment use screw #2. When moving the assembly away from the edge of the bench, the base plate may need some assistance. Use a balldriver or a screwdriver to lever the assembly over.

9) For vertical adjustment, use screws A, B and C. Screws A and B should be adjusted equally to avoid any rotation of the rod. Adjust all theree screws evenly to raise the head. Adjust C for tilt.

10) Tighten all 9 locking screws. Confirm that the head is still aligned. If not, you may need to shift the head to compensate for any movement that occurs while locking.

11) Replace first amplifier and repeat steps 8 through 10 with this head.

12) Remove HeNe, alignment mirrors and fixtures.

NOTE:

The burn pattern should be a sharply defined dark brown circle. Within the circle there should be another round image that is slightly smaller then the dark brown one. This smaller image will be a lighter color which indicates higher energy. When the the beam is perfectly aligned through the aperture the light brown image will be centered on the dark one.

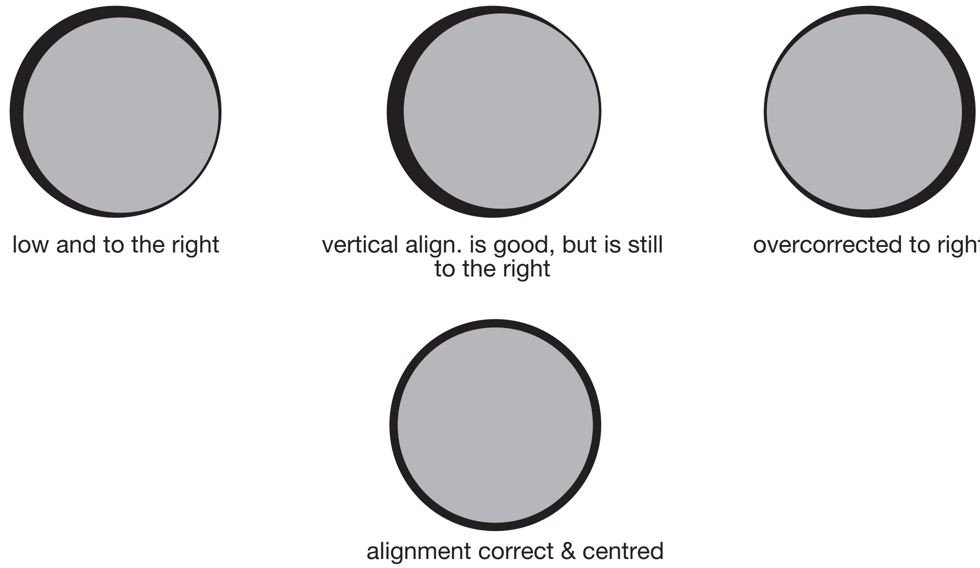
Determine if the oscillator beam is well aligned through the aperture. If the light brown image is not centered on the dark brown circle then adjustments will have to be made.

I. Precision II Dual amplifier IR alignment

1) Keep amplifier PU off. Attenuate the oscillator by either lowering the pump voltage or delaying off the Q-switch.

2) Slide mirror 7c until beam is centered entering the telescope. Adjust angle so the beam is parallel to the end of the bench. See diagram, page 5-20.

3) Replace the two pinhole alignment fixtures back in the dowel pin locations before the first amplifier and after the second amplifier.



Amplifier alignment burn patterns.

4) Slide mirror 7d until beam is parallel to the side of the bench and centered on the pinhole.

5) Use mirror 7c to center the beam on the first pinhole and use mirror 7d to center the beam on the second pinhole.

6) Remove the pinholes.

7) Turn the oscillator back up to normal operating energy.

8) Adjust mirror 7c for a symmetric beam, looking with orange fluorescent paper just after the second amplifier.

9) Move the orange paper out to the beam dump and adjust mirror 7d to eliminate any caustic.

10) Repeat steps 8 and 9 until the beam image looks good at both places. Turn on the amplifiers and confirm that they are aligned.

11) Install and adjust the quartz rotator (see procedure below).

12) Install and adjust apertures so that they are centered on the input IR.

J. Quartz rotator alignment procedure for Precision II 9000

The quartz rotator, P/N 199-0067, converts horizontal polarization to vertical and vertical polarization to horizontal. With the rotator between the two amplifier rods, the depolarization due to birefringence in the first rod is undone by the second rod.

1) Remove any waveplates from in front of the amplifiers.

2) Place a Glan Taylor or dielectric polarizer after the second amplifier. With the rotator in place most of the energy will be converted to vertical polarization and therefore rejected off the Glan Taylor (or dielectric). Be sure to dump the rejection.

3) Place a power meter to measure the beam transmitted through the Glan Taylor. This should be weaker than the rejected beam.

4) With the oscillator Q-switching and the amplifiers on, adjust the quartz compensator by rotating the mount to minimize the power transmitted.

K. Amplifier Alignment Single Rod Heads for Precison II 8000

Equipment needed:

- burn paper
- clear plastic bags
- 1 metric Allen wrench set
- 1 Phillips screwdriver
- high density styrofoam beam dump

1) For this alignment the amplifier must be turned off. To turn off the amplifier do the following:

a. Turn off rack main breaker located front right hand corner.

b. At rear of rack remove cover plates so that you can access rear of amplifier capacitor bank CB631C or CB632C.

c. Disconnect at rear of capacitor bank the High Voltage BNC that runs from power unit to capacitor bank.

d. Now, power the system back up and activate PGM-1 to allow the system to warm up. Only the oscillator should be flashing at this time.

2) On the RB601 activate PGM-2, turn on **SHUTTER** and **Q-SWITCH** and then press **FIRE** to take single shot oscillator burns.

Note:

The oscillator must be properly aligned before attempting to adjust the amplifier. If the oscillator is not aligned then refer to the oscillator alignment and optimization section (page 5-12).

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3) On the RB601 turn off **SHUTTER** and **Q-SWITCH.**

4) Position the burn paper (placed inside a plastic bag) on the laser bench between the aperture and the amplifier head.

5) The emulsion side of the paper should face the incoming beam.

6) On RB601 turn on **SHUTTER** and **Q-SWITCH** and then press **FIRE** to get a single shot burn pattern.

7) On RB601 turn off **SHUTTER** and **Q-SWITCH.**

8) Remove the burn paper from the plastic bag and examine the burn pattern. Refer to the amplifier burn patterns, p. 5-23.

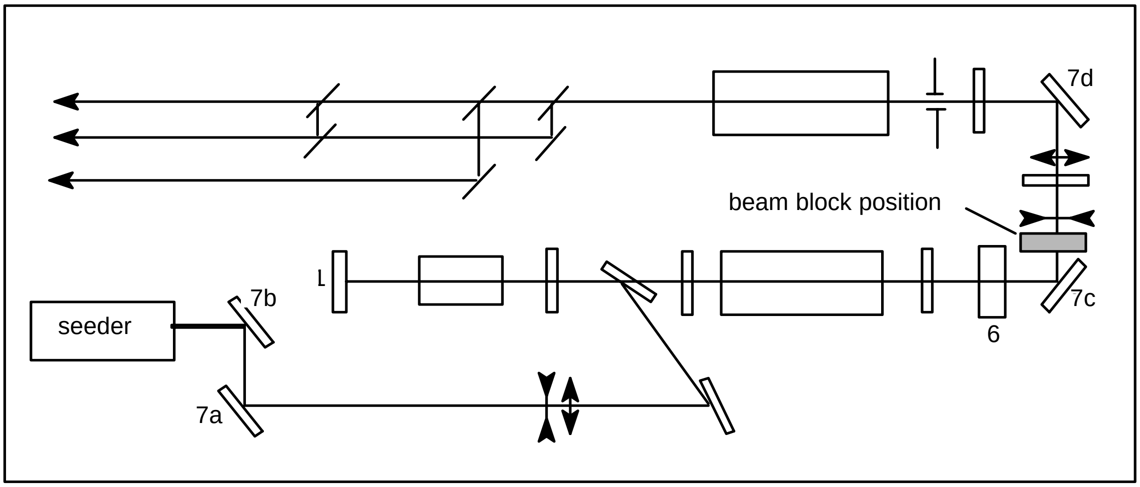
Note:

The burn pattern should be a sharply defined dark brown circle. Within the circle there should be another round image that is slightly smaller then the dark brown one. This smaller image will be a lighter color which indicates higher energy. When the the beam is perfectly aligned through the aperture the light brown image will be centered on the dark one.

---

9) Determine if the oscillator beam is well aligned through the aperture. If the light brown image is not centered on the dark brown circle then adjustments will have to be made.

10) Adjust the 7c mount. The screws located on the top of the mounts control the vertical and horizontal axes.



11) Once the aperture alignment is correct, then the alignment through the amplifier can be checked.

12) Position the burn paper (inside a plastic bag) approximately 4 inches from the output of the amplifier head.

13) On RB601 turn on **SHUTTER** and **Q-SWITCH** and then press **FIRE** to get a single shot burn pattern.

14) On the RB601 turn off **SHUTTER** and **Q-SWITCH.**

15) Remove the burn paper from the plastic bag and carefully examine the burn pattern (see page 5-24).

Note:

Once again the pattern will have two images. The smaller lighter image should be centered on the larger darker image.

16) Adjust the 7d mount. The screws located on the top of the mounts control the vertical and horizontal axes. Adjust this mount to align the oscillator beam through the amplifier.

17) Make a small adjustment to the 7d mount and then repeat the previous 4 steps until the alignment through the amplifier is correct.

18) Once satisfied with the amplifier alignment, take burn patterns after second and third harmonic crystals to verify that the amplifier output passes cleanly through these crystals.

19) Reconnect power to amplifier capacitor bank:

  a. Turn off rack main breaker located on front right hand corner.

  b. At rear of rack replace cover plates.

  c. Reconnect at rear of capacitor bank the high voltage BNC that runs from power unit to capacitor bank.

20) Amplifier alignment is now complete. Replace all covers and lids that were removed, log work done and proceed with normal operation.

L. Flashlamp voltage adjustment

Equipment needed:

- power meter
- IR card

It is common for flashlamps to last 20-30 million shots. But during that time the efficiency of the lamps will decline. It is possible initially to compensate for the decline by increasing pump voltage. However, after a point the thermal loading on the YAG rod becomes too great. At that point the flashlamp should be replaced.

1) Before increasing pump voltage to bring laser output back to spec, make sure that your power decrease is not due to misalignment or optical damage.

2) Position power meter to monitor IR energy.

3) Increase pump voltage on power unit by 20 V.

4) Check free-running buffer. It must be at least 100 V. See procedure page 5-18.

5) Open the intracavity shutter, allow the laser to Q-switch and measure the energy.

6) Compare the energy reading to the original installation energy.

7) If still below specs, repeat steps 3 thru 6.

If total voltage increases exceed installed voltage by more than 100 V, then the flashlamps should be replaced.

8) If the energy is back to its spec level, then note the voltage setting in users log and resume normal operation.

M. Cooling group contamination

Equipment needed:

- 1 pint (~.5l) 3.0% hydrogen peroxide
- 10 gal. distilled water
- 1 DI filter

The purpose of this section is to describe the procedure for flushing the cooling group if it becomes contaminated with organic material (algae).

1) Shut down system.

2) Remove the four Phillips head screws that hold the CB604C cooling group in the power cabinet.

3) Pull the cooling group out far enough to gain access to the fill port located on the top of the water reservoir.

4) Using an inspection light look into the tank. Note any signs of floating white, green, or brown contamination.

5) If contamination is present, then the unit will have to be flushed.

6) Drain cooling group and refill with new distilled water.

7) Remove old DI filter and pinch off DI filter water lines.

8) Add 1 pint (~500 ml) of 3.0% hydrogen peroxide to distilled water in reservoir.

9) Allow the peroxide to circulate for 1 hour.

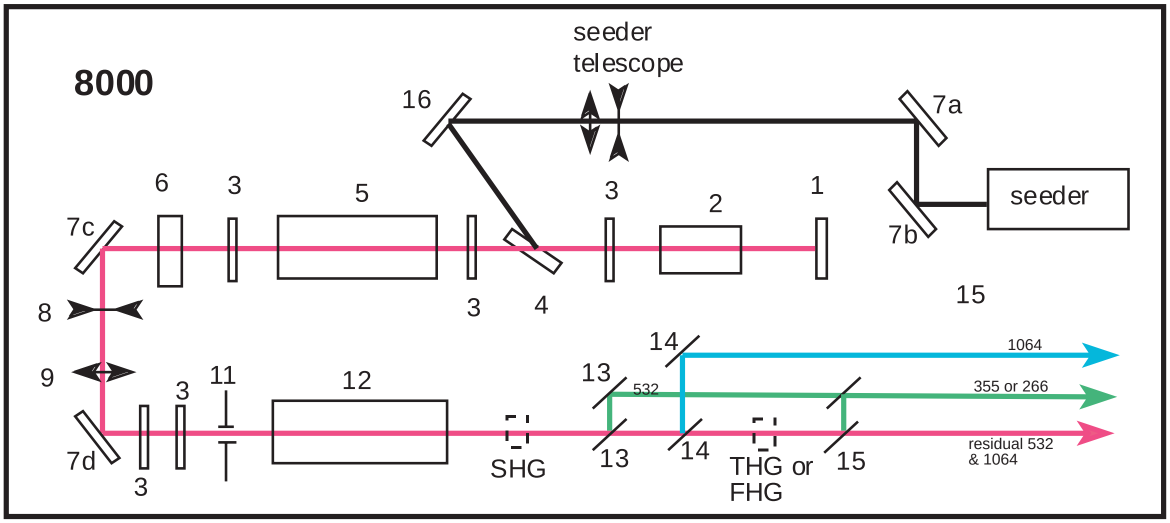
10) Turn the cooling group off and drain the reservoir.

11) Repeat steps 1 through 5 once again.

12) Install new DI filter and fill reservoir with distilled water.

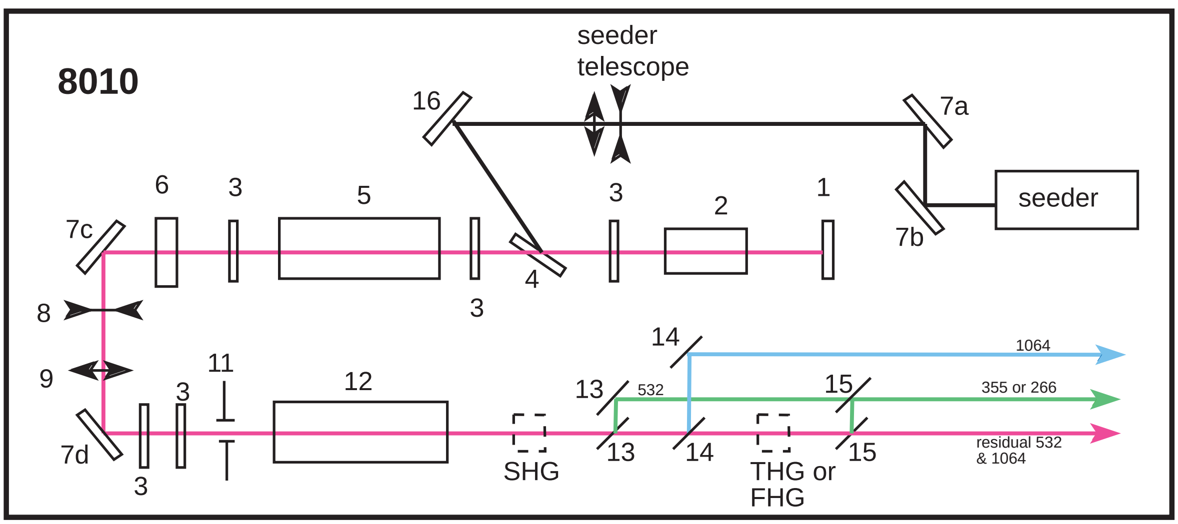
13) Log date and work done and resume normal operation.

Chapter VI Parts Lists Contents



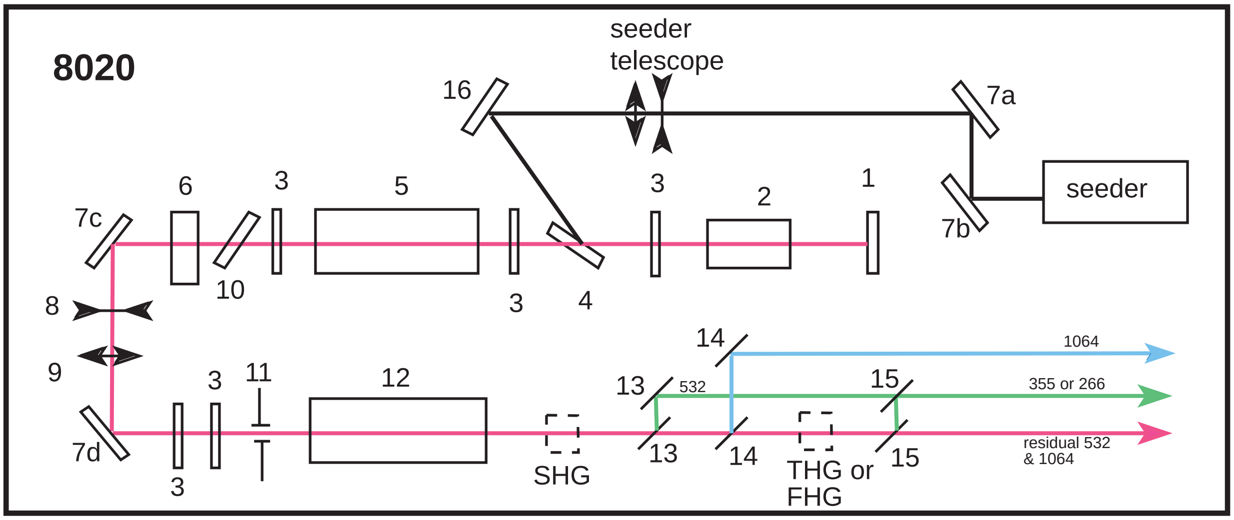
Legend for Precision 8000

1. Mirror, rear, (rep rate dependent)
2. Pockels cell, 202-0003
3. λ/4 plate, 108-0001
4. Dielectric polarizer, 199-0116
5. 811U-06 head, 507-0700
   rod, 6mm, 201-0056
   flashlamp, 203-0019
6. Output coupler, (rep rate dependent)
7. Mirror, turning, 45°, 105-0002
8. Div. lens, -104mm, 102-0005
9. Con. lens, +155mm, 101-0001
10. Not used
11. Pinhole
12. 812V-09 head, 507-0900
    rod, 9mm, 201-0005
    flashlamps, 203-0032
13. Dichroics, 532nm, 105-0022
14. Dichroics, 1064nm, 105-0002
15. Dichroics. 355nm, 105-0023
    or 266nm, 105-0025
16. Mirror, 20-32°, 105-0086



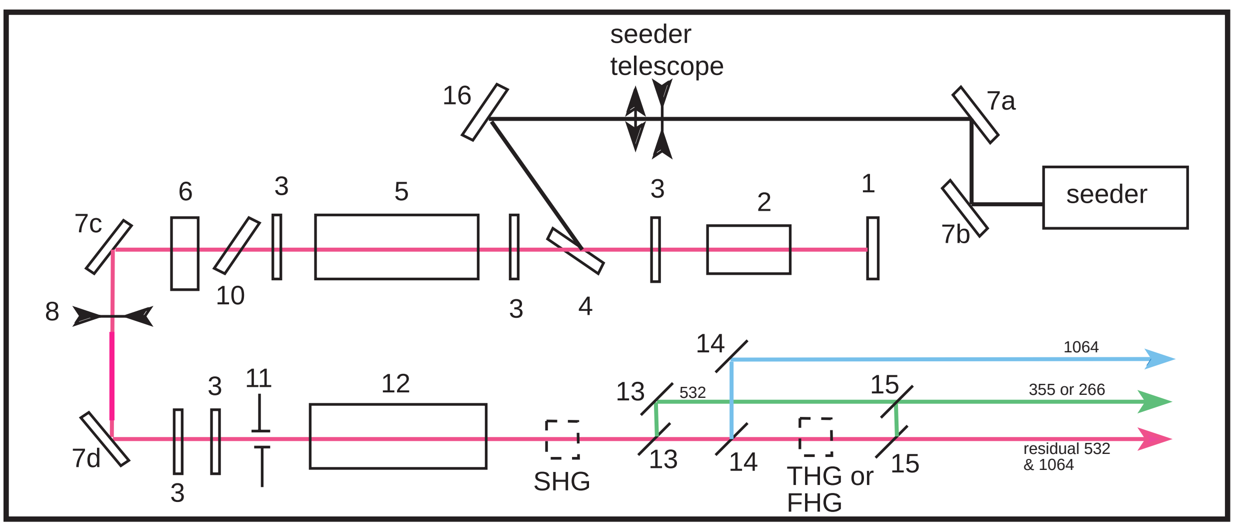
Legend for Precision 8010

1. Mirror, rear, (rep rate dependent)
2. Pockels cell, 202-0003
3. λ/4 plate, 108-0001
4. Dielectric polarizer, 199-0116
5. 811U-07 head, 507-1000
   rod, 7mm, 201-0004
   flashlamp, 203-0035
6. Output coupler, (rep rate dependent)
7. Mirror, turning, 45°, 105-0002
8. Div. lens, -104mm, 102-0005
9. Con. lens, +155mm, 101-0001
10. Not used
11. Pinhole
12. 812V-09 head, 507-0900
    rod, 9mm, 201-0005
    flashlamps, 203-0032
13. Dichroics, 532nm, 105-0022
14. Dichroics, 1064nm, 105-0002
15. Dichroics. 355nm, 105-0023
    or 266nm, 105-0025
16. Mirror, 20-32°, 105-0086



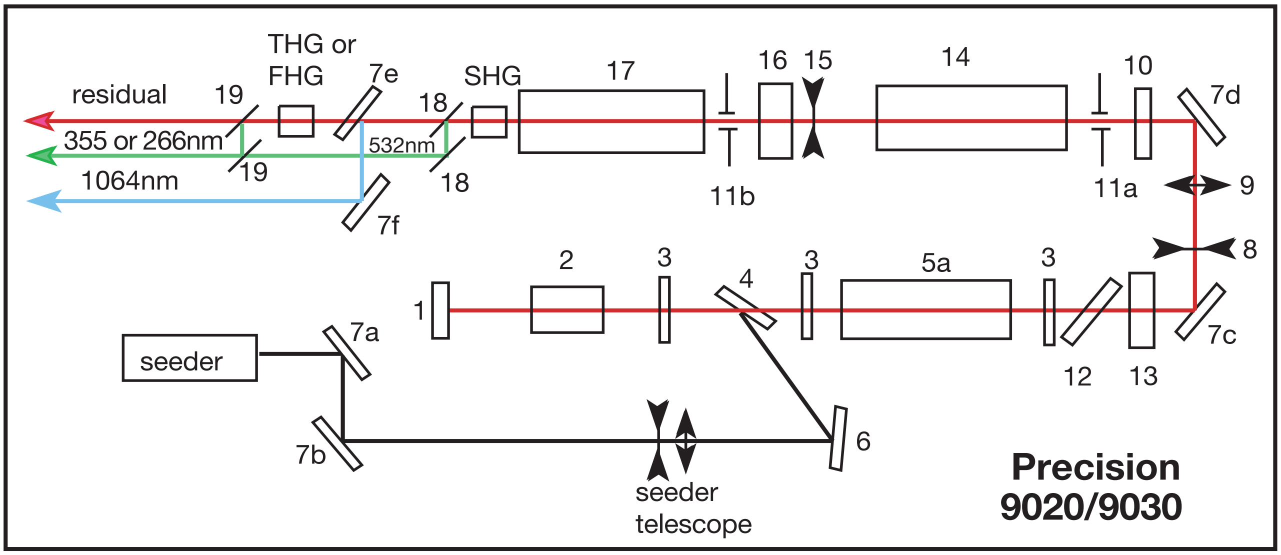
Legend for Precision 8020

1. Mirror, rear, (rep rate dependent)
2. Pockels cell, 202-0003
3. λ/4 plate, 108-0001
4. Dielectric polarizer, 199-0116
5. 811U-06 head, 507-0700
   rod, 6mm, 201-0056
   flashlamp, 203-0019
6. Output coupler, (rep rate dependent)
7. Mirror, turning, 45°, 105-0002
8. Div. lens, -104mm, 102-0005
9. Con. lens, +155mm, 101-0001
10. Dielectric polarizer, 199-0055
11. Pinhole
12. 812V-09 head, 507-0900
    rod, 9mm, 201-0005
    flashlamps, 203-0032
13. Dichroics, 532nm, 105-0022
14. Dichroics, 1064nm, 105-0002
15. Dichroics. 355nm, 105-0023
    or 266nm, 105-0025
16. Mirror, 20-32°, 105-0086



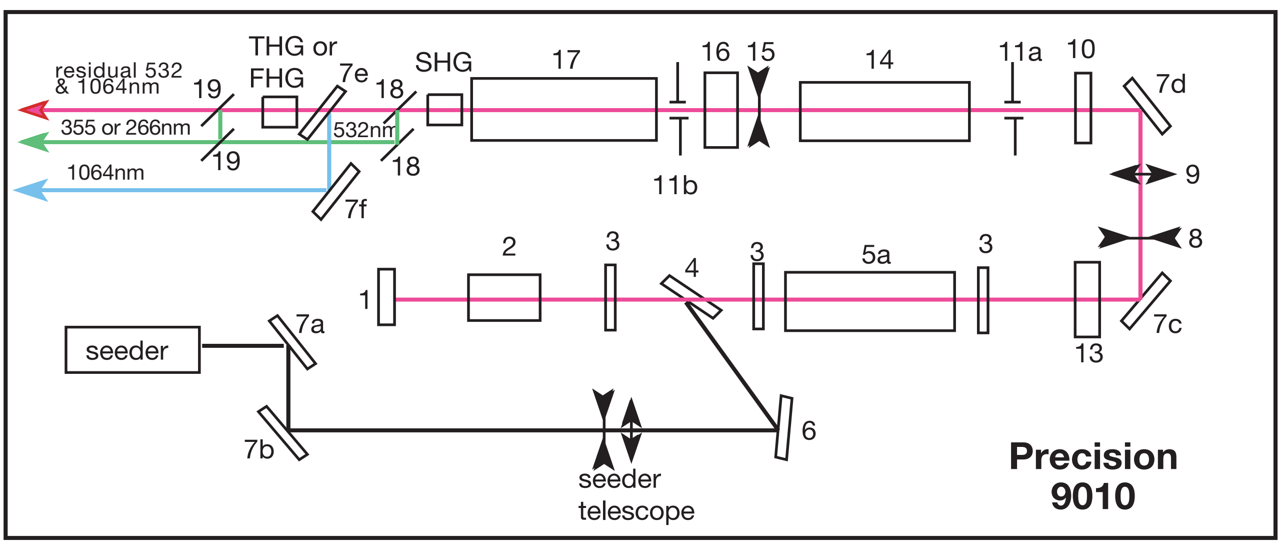
Legend for Precision 8030

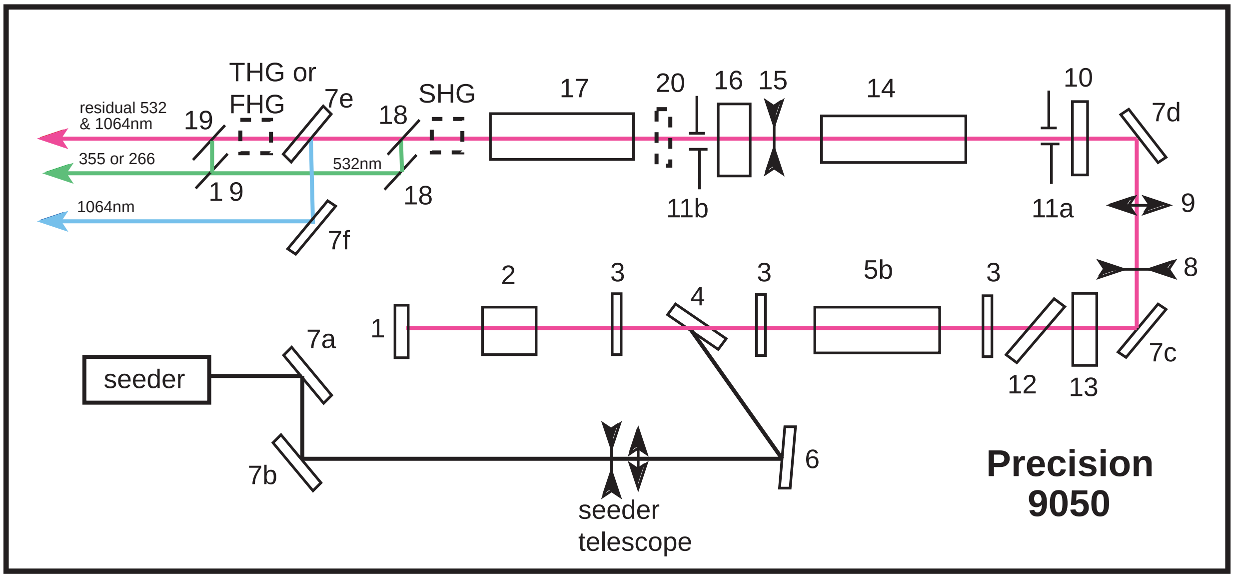
1. Mirror, rear, (rep rate dependent)
2. Pockels cell, 202-0003
3. λ/4 plate, 108-0001
4. Dielectric polarizer, 199-0116
5. 811U-06 head, 507-0700
   rod, 6mm, 201-0056
   flashlamp, 203-0019
6. Output coupler, (rep rate dependent)
7. Mirror, turning, 45°, 105-0002
8. Div. lens, -2m, 102-0013
9. not used
10. Dielectric polarizer, 199-0055
11. Pinhole
12. 811U-06 head, 507-0700
    rod, 6 mm, 201-0056
    flashlamp, 203-0019
13. Dichroics, 532nm, 105-0022
14. Dichroics, 1064nm, 105-0002
15. Dichroics. 355nm, 105-0023
    or 266nm, 105-0025
16. Mirror, 20-32°, 105-0086



Legend for Precision 9010, 9020 & 9030

1. Mirror, rear, (rep rate dependent)
2. Pockels cell, 202-0003
3. λ/4 plate, 108-0001
4. Dielectric polarizer, 199-0116
5a. 811U-06 head, 507-0700
    (for 10, 20 & 30Hz)
    rod, 6mm, 201-0056
    flashlamp, 203-0019
6. Mirror, turning, 30°, 105-0086
7. Mirror, turning, 45°, 105-0002
8. Div. lens, -104mm, 102-0005
9. Con. lens, +155mm, 101-0001
10. λ/2 plate, 108-0004
11a. Pinhole, 9.0mm, 314-0176
11b. Pinhole, 9.5mm, 314-0317
12. Dielectric polarizer, 199-0055
13. Output coupler, (rep rate dependent)
14. 811D-09 head, 507-0770
    rod, 9mm, 201-0005
    flashlamp, 203-0036
15. Div. lens, rep rate dependent
16. Rotator, quartz, 199-0067
17. 811U-09 head, 507-0750
    rod, 9mm, 201-0005
    flashlamp, 203-0036
18. Dichroics, 532nm, 105-0022
19. Dichroics. 355nm, 105-0023
    or 266nm, 105-0025





Legend for Precision 9050

1. Mirror, rear, (rep rate dependent)
2. Pockels cell, 202-0003
3. λ/4 plate, 108-0001
4. Dielectric polarizer, 199-0116

5b. 811U-05 head, 507-1700
(for 50 Hz)
rod, 5mm, 201-0094
flashlamp, 203-0019

6. Output coupler, (rep rate dependent)
7. Mirror, turning, 45°, 105-0002
8. Div. lens, -91.4mm, 102-0002
9. Con. lens, +155mm, 101-0001
10. λ/2 plate, 108-0004

11a. Pinhole, 9.0mm, 314-0176
11b. Pinhole, 9.5mm, 314-0317

12. Dielectric polarizer, 199-0055
13. Output coupler, (rep rate dependent)
14. 811D-09 head, 507-0770
rod, 9mm, 201-0005
flashlamp, 203-0032
(for 9050 only)
15. Div. lens, rep rate dependent
16. Rotator, quartz, 199-0067
17. 811U-09 head, 507-0750
rod, 9mm, 201-0005
flashlamp, 203-0032
18. Dichroics, 532nm, 105-0022
19. Dichroics. 355nm, 105-0023
or 266nm, 105-0025
20. Lens, cyl., (rep. rate dependent)

Part numbers for Precision II heads.

Precision II											
Part	**P/N**	**8000**	**8010**	**8020**	**8030**	**8050**	**9010**	**9020**	**9030**	**9050**	**Plus**
811U-05 head assy. cladding only rod flashlamp “O” ring kit	507-1700 507-0725 201-0094 203-0019 507-1705									osc.	
811U-06 head assy. cladding only rod flashlamp “O” ring kit	507-0700 507-0725 201-0056 203-0019 507-0710	osc.			osc. & amp	osc. & amp	osc.	osc.	osc.		osc.
811U-07 head assy. cladding only rod flashlamp “O” ring kit	507-1000 507-0725 201-0004 203-0035 507-1005		osc.	osc.							
811U-09 head assy. cladding only rod flashlamp <50Hz “O” ring kit	507-0750 507-0765 201-0005 203-0036 507-0775						amp.	amp.	amp.	amp.	
811D-09 head assy. cladding only rod flashlamp PL9050 “O” ring kit	507-0770 507-0785 201-0005 203-0032 507-0775						amp.	amp.	amp.	amp.	
812H-12 head assy. cladding only rod flashlamp PL9050 “O” ring kit	507-0950 507-0965 201-0057 203-0032 507-0975										amp.
812V-12 head assy. cladding only rod flashlamp PL9050 “O” ring kit	507-0970 507-0985 201-0057 203-0032 507-0975										amp.
812V-09 head assu. Cladding only rod flashlamp PL9050 "O"ring kit	507-0970 507-0985 201-0057 203-0032 507-0975	amp.	amp.	amp.							

Electronics & Supplies		
Part Number	**Description**	**Quantity**
504-3100	Marx PCB, 750V	1
504-3200	Power board, 750V	1
601-7200	PCB crystal oven	1
504-4400	Logic PCB, PU610C series	1
425-0013	24V power supply	1
421-0008	CB630C & CB631C trig. trans.	1
421-0042	CB632C & CB634C trig. trans.	1
504-6400	CB simmer PCB	1
504-4200	Assy, PCB PU630C pwr. brd.	1
313-0099	DI filter	1

Optics/Electro-optics (refer to drawing p. 3-1)		
Part Number	**Description**	**Quantity**
rep rate dependent - consult factory for part	Rear mirror	1
rep rate dependent - consult factory for part	Output coupler, Gaussian	1
105-0022	Dichroics, 532nm	2
105-0023	Dichroics, 355nm	2
199-0116	Polarizer, plate	1
202-0001	Pockels cell	1
617-8000	SHG crystal	1
617-8020	THG, crystal	1

Chapter VII Appendix Contents

Chapter VII Appendix

A. Express warranty

Unless otherwise specified, all mechanical, electronic and electro-optical assemblies manufactured by Continuum are warranted to be free from defects in workmanship and materials for a period of two (2) years from date of shipment.

Exclusions are:

1) optics, crystals and flashlamps which are warranted for 90 days.

2) the Lightwave® Injection Seeder (SI-500) which is warranted for one year from date of shipment.

B. Limitation of remedy

The remedy available under this warranty shall be the repair of the defective material so long as the following are observed:

1) This warranty does not apply to equipment or components which inspection by Continuum shall disclose to have become defective or unworkable due to abuse, mishandling, misuse, accidental alteration, negligence, improper operation or other causes beyond Continuum's control

2) This warranty shall not apply in the event that the original device identification markings have been removed, defaced or altered or if any parts have been substituted or modified without the express consent of Continuum

3) The customer's general account at Continuum is current and not delinquent in whole or in part.

C. Disclaimer of implied warranty

The foregoing is in lieu of all other warranties Express or Implied, and there are no warranties of Merchantability or fitness or any other remedies available other than as expressed herein.

D. Returns, adjustments & servicing

If warranty or general repair or service to a Continuum product is requested by the customer involving the product's return to Continuum, the terms of the return shall include the following:

1) The customer shall obtain a return authorization number from the Continuum Service Department

2) The product must be properly packed in the original Continuum shipping container. Additional shipping containers may be purchased from Continuum if needed. All water must be removed from the water-cooled products prior to packing

3) Freight and insurance (for the full value of the shipped goods) charges must be prepaid by the Buyer and all risk of loss, damage or delay in shipment shall be borne solely by the Buyer

4) After receipt of product, Continuum reserves the right to inspect the product and to determine the cause of failure and warranty status. Continuum shall have no duty to perform a warranty repair where the product has suffered damage in shipment that prevents a determination by Continuum of the cause or existence of the asserted defect

5) If the product is found to be under warranty it will be repaired or replaced free of charge in accordance with the terms of the Continuum warranty. The warranty period on a repaired or replacement product shall be the balance of the warranty period remaining on the original product, i.e. no new warranty is created by such a repair

6) If the product is determined to be of a non-warranty status the customer will be advised and a written purchase order for the repair or service work will be required before the work begins. The cost and terms of non-warranty service shall be according to Continuum's then prevailing policies which are subject to change.

E. Service information

Continuum service centers

Continuum 3150 Central Expressway Santa Clara, CA 95051, USA Continuum@ceoi.com www.continuumlasers..com	1 (408) 727-3240 1 (408) 727-3550 fax
Continuum GmbH Bochstrasse 12 D-82178 Puchheim, Germany cntgmbh@ccn.de	089 800 64 10 49 89 800 1279 fax
HOYA Continuum Corporation 23-2 Sakamachi Shinjuku-ku Tokyo, 160 Japan ssalehcc@marinet.or.jp	03 3353 5320 03 3353 6673 fax
Continuum 10 Boulevard Louise Michel 9100 Evry, France 101511.2621@compuserve.com	33 1 69 36 31 00 33 1 69 36 31 04 fax

F. Lightwave® Seeder Manual

Series 101 User's Manual

Published by

Lightwave® Electronics,

Rev. X1, 28 June 2000

SERIES 101

USER'S MANUAL

LIGHTWAVE®
ELECTRONICS

D-0883 REV. X1 6/28/00

PREFACE

Thank you for purchasing this Lightwave Electronics' product. We are confident this product will serve you well. Any comments you have concerning our product or your application are encouraged. Please feel free to call, Fax or E-mail us at:

Sales: 1.888.LIGHTWAVE (544-4892)
Service: 1.888.LWESERV (593-7378)
Operator: (650) 962-0755
FAX: (650) 962-1661
E-mail: Sales@lwecorp.com
Service@lwecorp.com
Internet: http://www.lwecorp.com

This manual should be comprehensive and easy to understand. However, should you be uncertain about how to do something, or the consequences of doing something, feel free to contact Lightwave. We'll be glad to answer any questions you may have. Also, if you have any comments on improving this manual, we would appreciate hearing from you.

A BRIEF OVERVIEW OF LIGHTWAVE ELECTRONICS

Lightwave Electronics was established in late 1984 to engage in various opportunities within the laser and electro-optical markets. Since its inception, Lightwave has actively designed, manufactured, and marketed laser-diode-pumped laser products and systems for end-users and original equipment manufacturers (OEMs). Applications include fiber-optic and free-space communications, fiber-optic sensing, semiconductor processing, and basic research and development. Lightwave also performs government and commercial contract research.

Through the years, Lightwave has established a substantial catalogue of diode-pumped, solid-state laser products that include CW, CW single-frequency, Q-switched, and mode-locked lasers. Lasers are available in a number of wavelengths, currently ranging from 0.5 µm to 2 µm, depending on the model. In addition, Lightwave has developed several laser accessories. Lightwave is committed to cultivating new technologies that will lead to additional future products.

PATENTS

This product is manufactured under one or more of the following U.S. patents:
4455657, 4578793, 4731787, 4734912, 4739507, 4749842, 4752931, 4764933, 4797896, 4809291, 4827485, 4829532, 4909612, 4947402, 4998255, 5076678, 5103457, 5130995.
Additional patents pending.

WARRANTY

Lightwave Electronics Corporation ("Lightwave") warrants products of its manufacture against defective materials and workmanship for a period of one (1) year from the date of installation by the purchaser or, if shorter, for a period of thirteen (13) months from the date of shipment to the purchaser. The liability of Lightwave under this warranty is limited, at Lightwave's option, solely to repair or replacement with equivalent products, or an appropriate credit adjustment not to exceed the sales price to the purchaser, provided that

(a) Lightwave is notified in writing by the purchaser within the warranty period promptly upon discovery of defects,
(b) the purchaser has obtained a Return Materials Authorization Number ("RMA") from Lightwave, which RMA Lightwave agrees to provide the purchaser promptly upon request,
(c) the defective products are returned to Lightwave, in the original packing material or alternate material approved by Lightwave, with transportation charges prepaid by the purchaser, and
(d) Lightwave's examination of such products discloses to its satisfaction that defects were not caused by **optical feedback, backpulse, negligence, misuse, improper installation, accident, or unauthorized repair or alteration.**

The original warranty period of any product which has been repaired or replaced by Lightwave shall not thereby be extended.

THE FOREGOING WARRANTY IS PROVIDED EXPRESSLY IN LIEU OF AND LIGHTWAVE HEREBY DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE, AND OF ALL OTHER OBLIGATIONS OR LIABILITIES ON LIGHTWAVE'S PART, AND LIGHTWAVE NEITHER ASSUMES NOR AUTHORIZES ANY OTHER PERSON TO ASSUME FOR LIGHTWAVE ANY OTHER LIABILITIES.

The foregoing warranty is only valid for Lightwave products sold in the United States. For products sold outside of the United States, please refer to the local authorized Lightwave distributor for applicable warranty terms and conditions.

LIMITATION OF LIABILITY

The remedies set forth above constitute the sole and exclusive remedies against Lightwave for the furnishing of nonconforming or defective products. In no event, including if the products are nonconforming, defective, delayed, or not delivered, shall Lightwave be liable for any special, contingent, indirect, or consequential damages, even if Lightwave has been advised of the possibility of such damages, whether under a contract, tort, property, or other legal theory. Such damages for which Lightwave is not responsible include, but are not limited to, personal injury, property damage, anticipated profits, labor expended, delays, and loss of use.

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The Series 101 injection seeding system provides single longitudinal (axial) mode CW output which results in single longitudinal mode pulsed output when mated with a Nd:YAG host laser. As an added benefit, by running in a single longitudinal mode the temporal profile of the pulsed output will be smoothed, and the energy stability will be significantly improved. This is even more apparent when the output from the Nd:YAG host laser is frequency doubled, tripled, or quadrupled.

The Series 101 requires a degree of theoretical knowledge for good operation of the laser system. For this reason, the theory underlying the injection seeding system is discussed first, and a description of the system and operation follows.

1.1 INJECTION SEEDING THEORY

Injection seeding refers to the process of achieving single longitudinal mode operation of a pulsed laser by injecting radiation from a very narrow linewidth, continuous-wave (CW) "seed" laser into the pulsed "host" laser cavity during the time the Q-switch opens. For injection seeding to work properly it is important that the seed laser emission be orders of magnitude more intense than any spontaneous noise emission also present in the host laser cavity.

When the seed laser frequency is within the bandwidth of a pulsed cavity mode (ie. it is resonant with the pulsed laser cavity) a Q-switched pulse will develop more rapidly out of this "seed" emission than it can out of background spontaneous noise emission. Consequently, the pulse developing out of the seed signal will saturate the gain medium and extract the energy (thereby depleting the gain) before a pulse which is simultaneously trying to grow out of noise emission. This inhibits amplification and growth of any pulse developing out of noise emission. Thus, all of the energy stored in a homogeneously broadened gain element[1], such as Nd:YAG, is depleted by the pulse which developed from the seed laser emission, resulting in single frequency output from the pulsed laser.

The sections that follow give a more detailed description of injection seeding with reference to the high power "host" lasers for which the injection seeding system was developed.

1.1.1   Longitudinal Modes of a Standing Wave Resonator

The basic elements of a typical electro-optically Q-switched laser are shown in Figure 1-1.

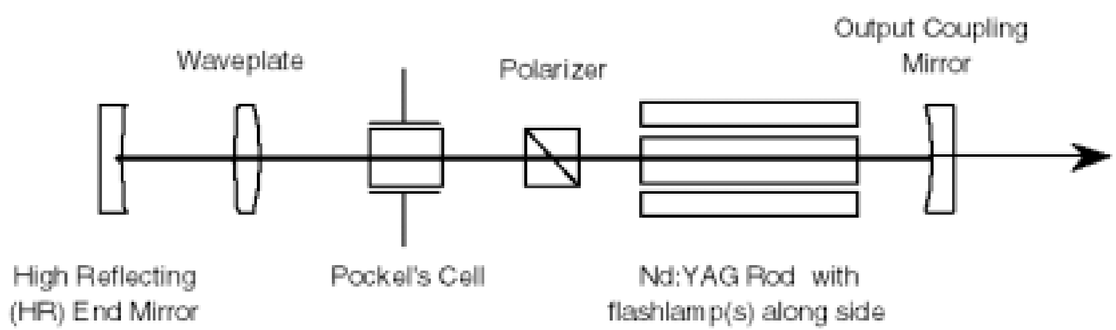


Figure 1-1: Optical Components of a Typical Host Resonator

The high reflecting mirror and output coupling mirror of the host laser form a Fabry-Perot resonator. The Fabry-Perot cavity supports specific resonant frequencies due to the constructive and destructive interference of counter-propagating waves within the resonator. The term longitudinal mode describes a condition where, at any given point along the resonator axis, a wave propagating between the two cavity mirrors will have exactly the same phase after a full round trip. Clearly there are many such longitudinal mode frequencies which meet this criteria and the spacing between longitudinal modes ($\Delta\varpi$) is referred to as the "Free Spectral Range" (FSR). The equation which gives the free spectral range is:

$$\Delta\varpi = FSR = c/2nL$$

where c=speed of light; and n is the index of refraction, and L is the physical path length of the host resonator.

Assuming most of the cavity is air (n=1), a host laser with a 60 cm resonator length yields:

$$\Delta\varpi = 3x10^{10} \text{ (cm/sec)}/2x1x60 \text{ (cm)} = 250 \text{ MHz}$$

Since the gain curve for Nd:YAG is ^{3}120 GHz (or 4 cm^{-1}) full-width half-maximum (FWHM), the Nd:YAG can support a large number of longitudinal modes. However, due to mode competition, longitudinal modes closest to the center of the gain curve capture most of the available energy at the expense of longitudinal modes further from the gain center. This generally results in a normal unseeded linewidth of about 1 cm^{-1} for the host laser. This is illustrated in Figure 1-2.

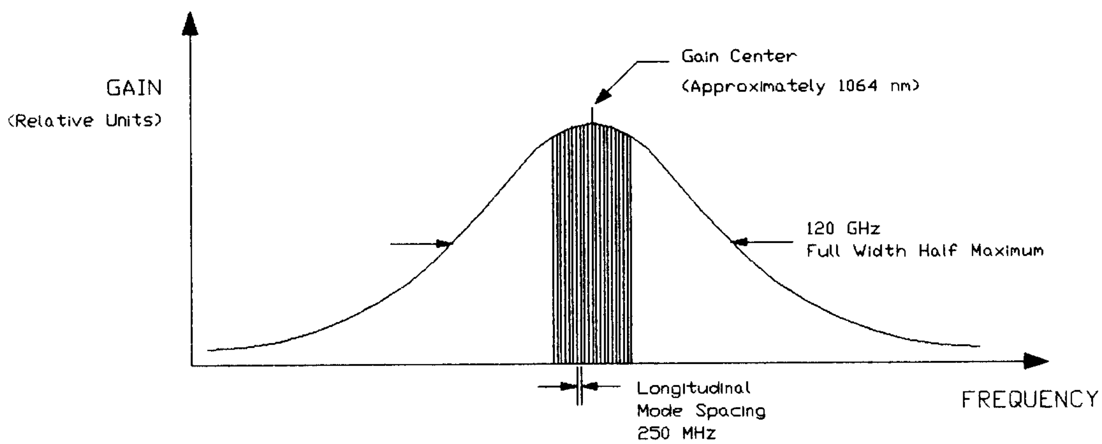


Figure 1-2: Longitudinal Modes of the Host Laser

Laser resonators have transverse ("spatial") modes in addition to longitudinal modes. Transverse modes, like longitudinal modes, have characteristic frequencies associated with them. It is imperative for injection seeding purposes that the pulsed Nd:YAG laser run in a single transverse mode (the lowest order transverse mode, TEM_{00}). Furthermore, the resonator should have a strong discrimination against the lasing of any higher order transverse modes.

1.1.2 Q-switch Buildup Time: Unseeded Operation

The Q-switch is included in the host resonator to initially inhibit lasing as the stored energy in the laser rod increases due to flashlamp emission. This ensures that the Nd:YAG rod in the host resonator has stored as much energy as possible. At full power this stored energy level can translate into a single pass ("small signal") gain in excess of 50.

When the stored energy in the Nd:YAG rod is at a maximum the Q-switch may be opened. Any light in the cavity possessing the proper frequency characteristics (ie. frequency within the gain bandwidth of Nd:YAG and resonant with a longitudinal mode of the host cavity) and spatial characteristics (ie. "on axis") of the host resonator is then repeatedly amplified by the Nd:YAG gain media. In the unseeded host this initial light within the cavity is broadband spontaneous noise emission from the Nd:YAG oscillator and amplifier rods. The spectral features of this noise emission are given by the fluorescence gain curve of Nd:YAG shown in Figure 1-2. This relatively weak spontaneous noise emission radiates in all directions leaving only a small power level (-nanowatts) sufficiently on axis to experience resonant amplification.

Consequently, as the Q-switch opens, this low level spontaneous emission must make a sufficient number of round trips through the Nd:YAG gain media to reach a fluence level comparable to the characteristic saturation intensity for Nd:YAG. With a small signal gain ž50 per pass, and accounting for output coupling losses, the pulse buildup typically requires about 12 resonator roundtrips. Given the speed of light and a resonator roundtrip length of 1.2 meters, 12resonator roundtrips corresponds to approximately 45 nsec.

When the amplified spontaneous emission reaches the saturation fluence, significant energy is extracted from the Nd:YAG rod lowering the gain to the large signal value of approximately 2.5 to 4 per pass. At this time the laser pulse begins to be emitted from the host laser. The observed output pulse width corresponds to the number of roundtrips required for circulating photons to extract all the energy stored in the Nd:YAG oscillator rod. The time from when the Q-switch opens until the laser pulse is emitted is termed the "Q-switch pulse build-up time".

1.1.3 Q-switch Buildup Time: Seeded Operation

During seeded operation very narrow linewidth (Ðν -5 kHz) laser emission of >1 milliwatt is directed into the host laser cavity on axis. If this "seed" emission is near the frequency of a host laser longitudinal mode, it will be resonantly amplified by the host when the Q-switch opens. Since the seed emission is more than 6 orders of magnitude stronger than the spontaneous noise, the Q-switch pulse builds up sooner out of the seed emission than the spontaneous emission.

Furthermore, when the amplified seed emission reaches the saturation intensity level, the gain in the oscillator rod is quickly reduced from the small signal level (>50) to the large signal level (2.5 to 4). This reduction in gain inhibits further amplification of spontaneous emission keeping it at a low level relative to the seeded output pulse. The difference in time between when a Q-switch pulse is emitted in seeded operation versus unseeded operation is termed the "build-up time reduction".

As a general rule, if the <u>reduction</u> in Q-switch build-up time is greater than a Q-switched pulse width (FWHM) there will be at least 1000 times more energy in the seeded longitudinal mode frequency than in any other longitudinal mode.

1.1.4 Frequency Control of the Host Laser

In the previous section reference was made to injecting seed radiation with the proper frequency characteristics into the host cavity. Since the seed and host cavities are independent entities, some form of frequency control and stabilization are required. The standard approach is to accurately stabilize the frequency output of the seed laser. Frequency overlap is then achieved via active control of the host laser's cavity length (frequency).

In practice the high reflecting mirror of the host resonator is mechanically translated by a piezoelectric element (piezo). Using a piezo as the active element in a feedback loop provides a way to lock the frequency of a host cavity mode to the seed frequency.

Since the temperature of the Nd:YAG rods of the host laser effects the effective cavity length of the host laser, it is also necessary to stabilize the temperature of the Nd:YAG rods in the host laser. This is done by temperature stabilizing the internal cooling water which cools the Nd:YAG rods. This provides a slow form of frequency control for the host laser such that it maintains roughly the same temperature in day to day operation. This also maintains the gain center of the host laser at a fixed point. (The gain curve of Nd:YAG is a (weak) function of temperature.) Having achieved coarse frequency overlap, a means for controlling the piezo must be developed. Figure 1-3 suggests that minimizing the Q-switch build-up time corresponds to proper injection seeding. Consequently, minimizing the Q-switch build-up time is the parameter employed to properly translate the piezo for precise frequency overlap with the seed laser. The Q-switch build-up time is measured electronically using the Q-switch trigger and a photodiode, which monitors the small amount of the laser pulse rejected into the seeder.

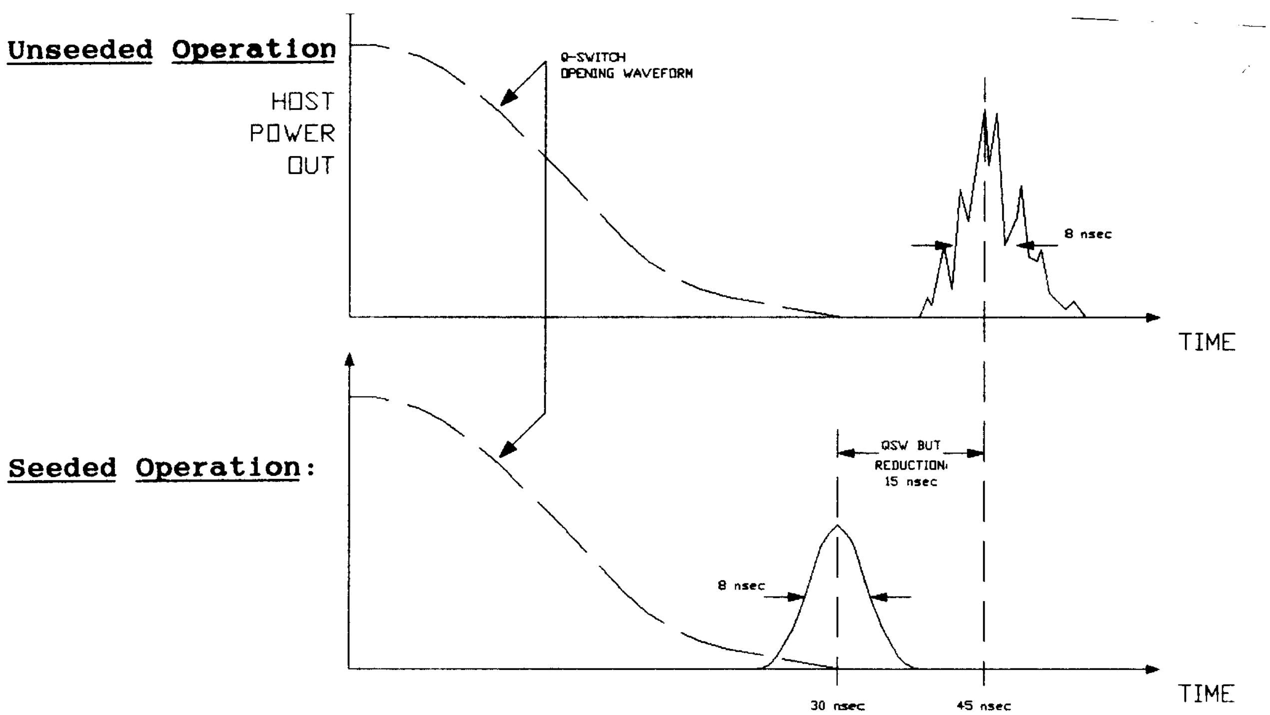


Figure 1-3: Q-switch Build-up Time Reduction

Figure 1-4 shows the Q-switch build-up time as the seed laser frequency is scanned through the host gain curve. The expanded view shows that, as the piezo is translated in either direction from the exact optimum frequency overlap condition, the effect on the Q-switch build-up time is the same.

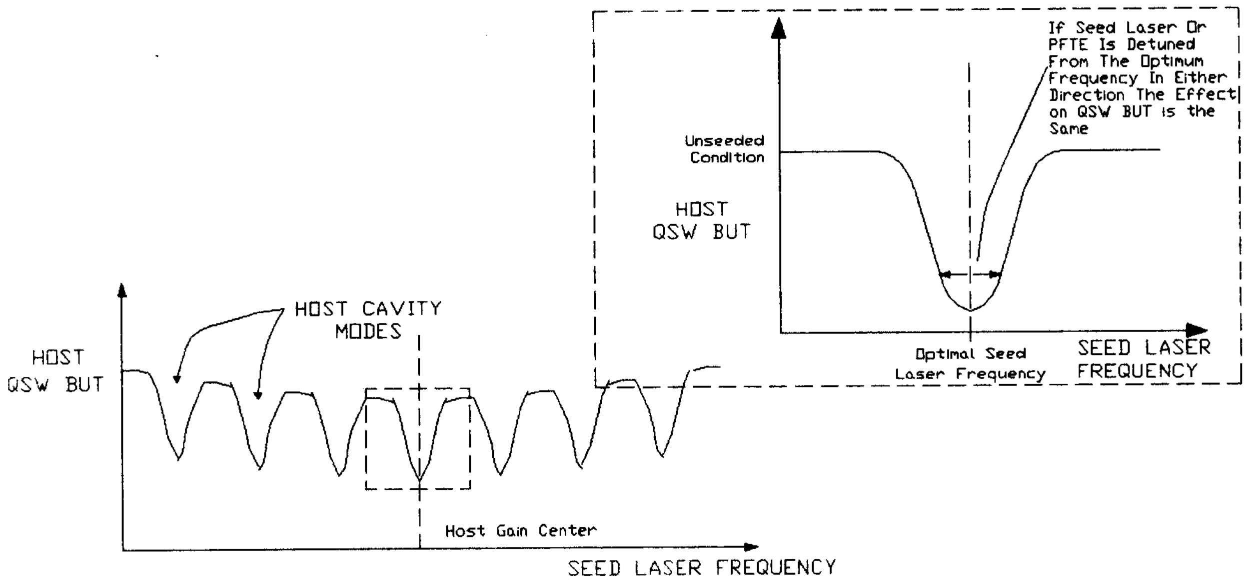


Figure 1-4: Host Laser Buildup Time vs. Seed Laser Frequency

The control loop block diagram for build-up time minimization is shown in Figure 1-5. To minimize the Q-switch build-up time, the control electronics develop an error signal using the derivative of the build-up time with respect to the host cavity length ($\partial T_b/\partial L$). This essentially is the slope of the curves in Figure 1-4. When the error signal is zero the Q-switch build-up time is minimized for that cavity mode. This signal is integrated over time to produce the piezo control voltage.

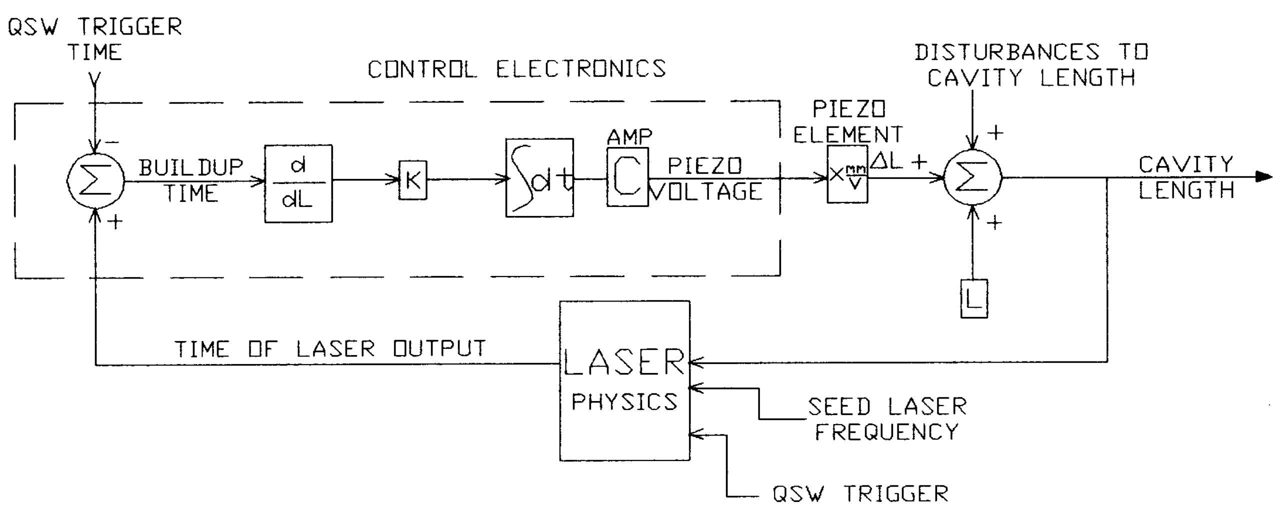


Figure 1-5: Frequency Control Loop-Block Diagram

The derivative, $\partial T_b/\partial L$, is developed by slightly changing or "dithering" the cavity length (and thus the laser output frequency), and measuring the change in the build-up time. The dither is produced by translating the piezo a small amount from its average position in an alternating fashion. On the first pulse the resonator is dithered to a slightly shorter length from its average length, and then dithered to a slightly longer length by the same amount on the subsequent pulse.

The exact frequency of the pulsed laser is determined absolutely by the physical spacing between its two resonator mirrors[4]. Because of this, the output frequency of the pulsed laser also will dither in proportion to dither applied to the piezo. Therefore, it is desirable to minimize the amount of dither required to maintain stable frequency overlap of the seed and pulsed lasers.

The dither necessary to achieve this goal is related to the overall stability of the pulsed laser. Frequency and energy instabilities in the pulsed laser translates into jitter in the Q-switch build-up time. This jitter is effectively "noise background" in which must be found the desired Q-switch build-up time error correction signal. For a typical laser the amount of dither required is typically less than ±2% of the resonator free spectral range (0.02 * 250 MHz = ±5 MHz). Such an amount of dither is minimal relative to the 60 MHz Fourier transform limited linewidth of a typical 8 nsec pulse.

1.1.5 Suppression of Spatial Hole Burning

When two counter-propagating waves of similar intensity and identical polarization and frequency are present in the same volume they will interfere in a classic standing-wave pattern. At every one-half wavelength from the fixed resonator mirror reflection points there will be nodes in the standing wave pattern. The term "spatial hole burning" refers to this phenomena as applied to a physically fixed gain media such as Nd:YAG. Figure 1-6 depicts this effect.

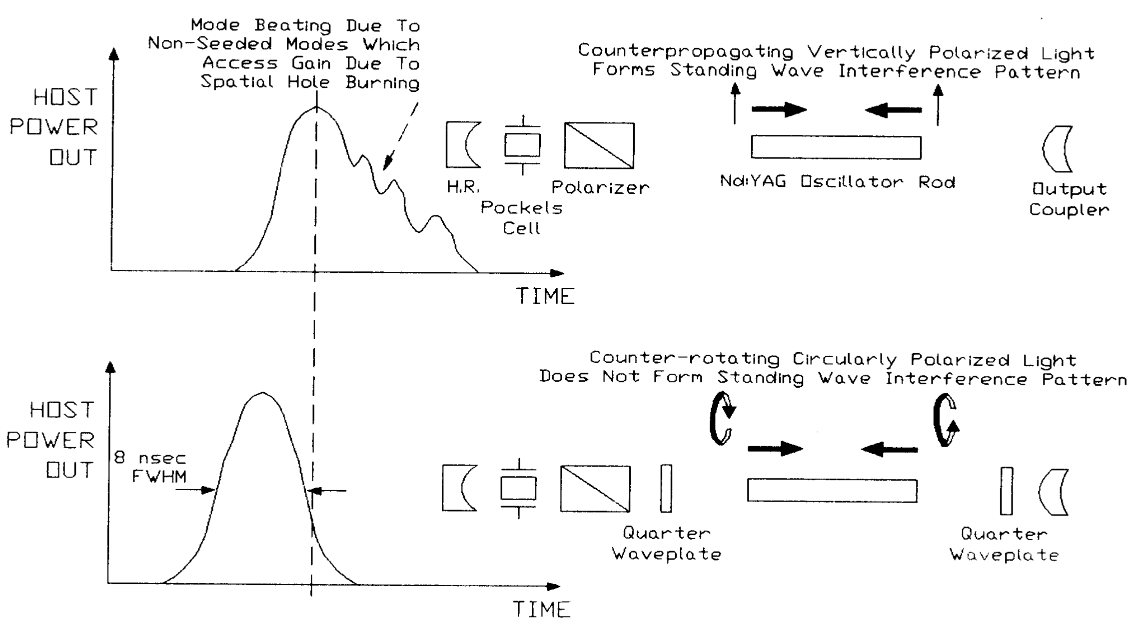


Figure 1-6: Spatial Hole Burning Effects

At the nodal points of the standing wave within the gain media the electric field vector is zero and hence no stimulated emission can occur. Since significant energy storage and gain can remain at these nodal points, light of such frequency as to have a non-zero field at the other frequency's nodal points can exceed threshold for lasing. The above describes the situation within a seeded host at the time of output pulse emission.

Consequently, the host would be expected to exhibit evidence of spatial hole burning (ie. multimode operation) unless the spatial hole burning is somehow suppressed. In practice these effects are indeed observed and the classic way of suppressing spatial hole burning is to ensure that the polarizations of the counterpropagating waves are orthogonal within the gain media[5]. This is conveniently achieved in the host resonator by surrounding the Nd:YAG rod with a pair of quarter-wave plates oriented so as to yield counter-rotating circularly polarized light within the Nd:YAG rod.

1.1.6 Frequency Control of the Injection Seeder

The frequency of the seed laser is temperature tunable. By changing the temperature of the monolithic seed laser crystal, its output can be tuned to the center of the host lasers gain curve. This position produces the most effective and stable seeding and also the highest seeded output power from the host laser.

Two temperature effects produce the movement of the seeder output frequency. The first is the combination of the expansion (or contraction) of the Nd:YAG crystal and the change in the Nd:YAG refractive index to produce a frequency shift of -3.1 GHz/°C in the Seeder resonator modes. The second is that the movement of the Nd:YAG gain center with temperature causes a frequency shift of approximately -1.4GHz/° C. These two effects combine to produce the frequency tuning curve shown in Figure 1-7. Note that approximately every 20 GHz the frequency "hops" back about 10 GHz. This is due to a new longitudinal mode moving to a position closer to the center of the gain curve of the seed laser.

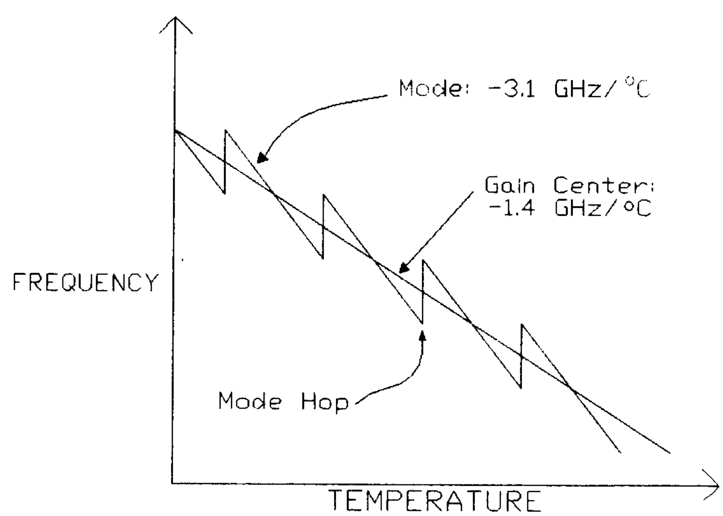
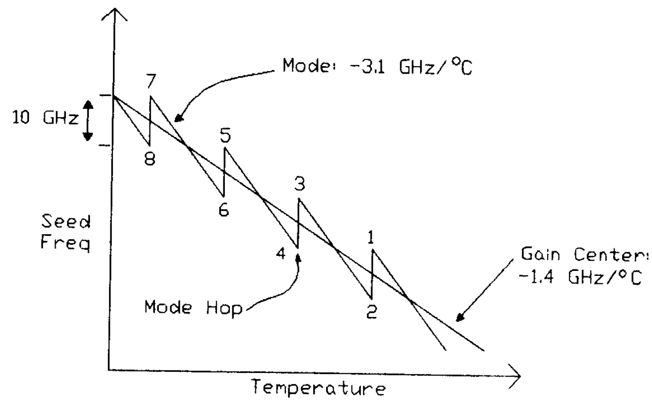


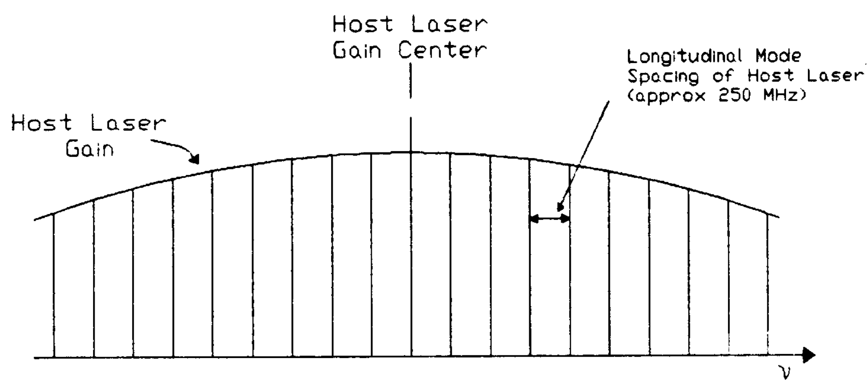
Figure 1-7: Frequency Tuning of the Injection Seeder

1.1.7 Frequency Overlap of Seeder and Host Laser

For proper seeding it is necessary that the frequency of the seed and host lasers overlap. As previously mentioned, this is done by tuning the temperature of the seed laser to match that of the host laser's Nd:YAG rods, and by temperature stabilizing the host laser's Nd:YAG rods to ensure long-term frequency overlap. Figure 1-8 depicts the seeder frequency tuning curve, the longitudinal mode spacing of the host laser, and the superposition of the seeder tuning curve on the host laser longitudinal modes.



Important Points on the Seeder Tuning Curve



Host Laser Modes

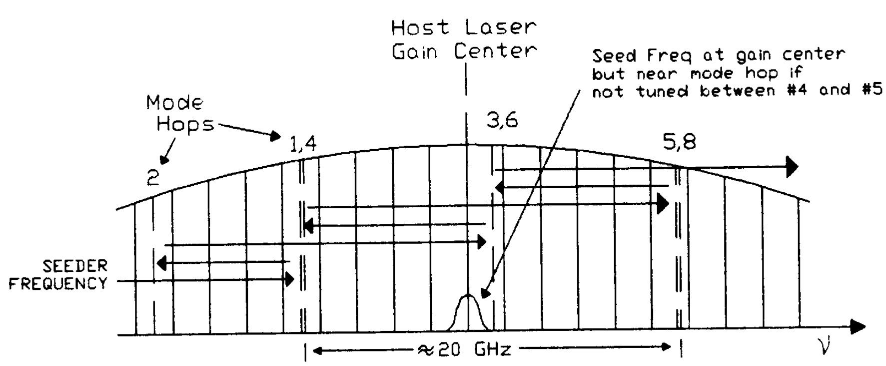


Figure 1-8: Proper Tuning of Seeder Frequency

1.2 DESCRIPTION OF SEEDER SYSTEM

A block diagram of the Series 101 injection seeding system is given in Figure 1-9. The elements of the system are described below.

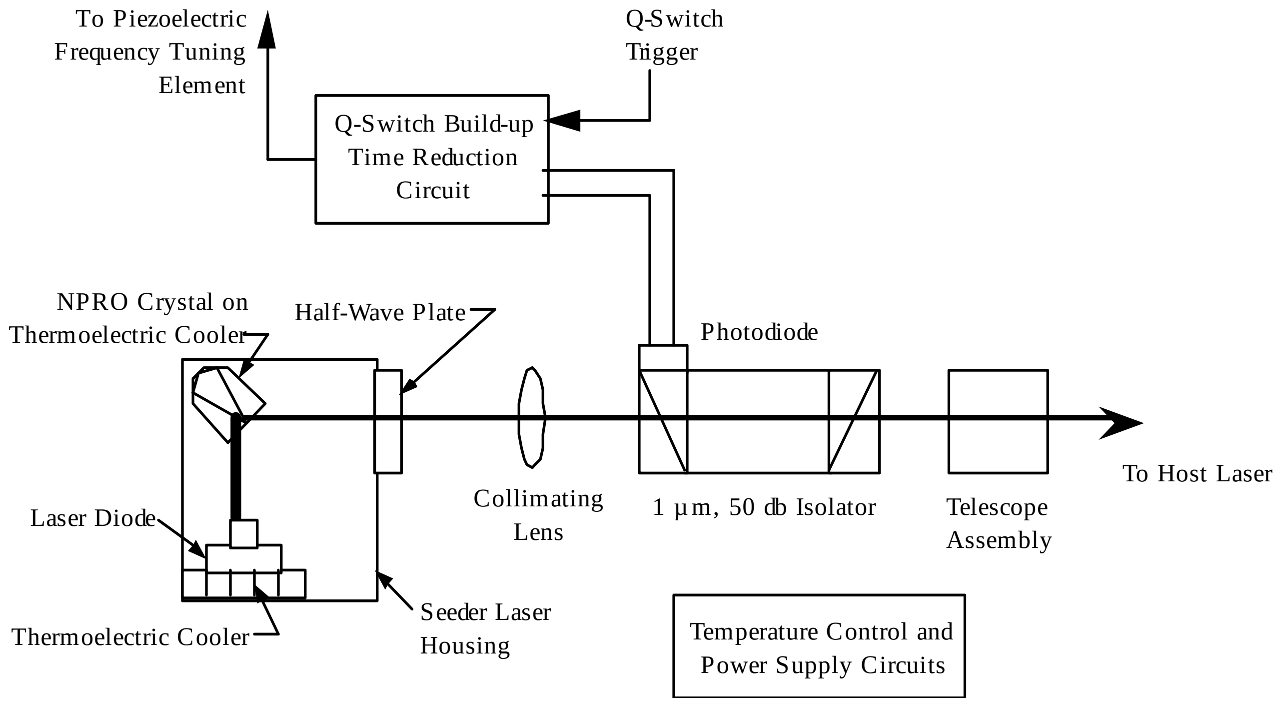


Figure 1-9: Injection Seeder Block Diagram

1.2.1 Seed Laser Source

The seed laser employed in the Series 101 is a monolithic, laser diode pumped, unidirectional ring resonator termed the NPRO (Non-Planar Ring Oscillator) or MISER (Monolithic, Isolated, Single mode, End pumped, Ring)[6]. The NPRO is a monolithic structure incorporating an effective half-wave plate polarization rotator, Faraday rotator, and polarizer. These three optical elements combine to yield lower losses for a complete transit of the ring resonator in one direction than for the other. This forces the ring resonator to lase in one direction only. The ring resonator is then a traveling wave in contrast to a standing wave resonator described previously. Because it is a traveling wave resonator, the NPRO does not suffer from the effects of spatial hole burning and consequently will lase in only a single longitudinal mode. See Section 1.1.7 for information on temperature tuning the NPRO output frequency.

The geometry of the NPRO is shown in Figure 1-10. Polarization takes placed at the curved, partially transmitting face (point A). At points B, C, and D, total internal reflection occurs. A magnetic field, H, is applied to establish unidirectional operation. Faraday rotation takes place along segments AB and DA. The focused pump laser beam enters the crystal at point A, and the output beam emerges at the same point.

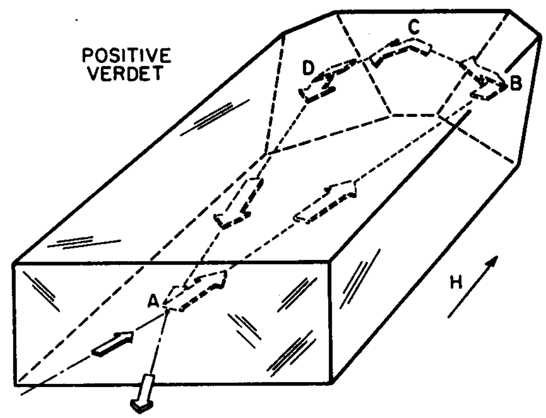


Figure 1-10: NPRO Laser Design

1.2.2 Collimating Lens and Half-wave Plate

The collimating lens is used to ensure that a small diameter, well collimated beam is transmitted through the Faraday isolator for maximum throughput and isolation. The half-wave plate matches the NPRO output polarization to that of the Faraday isolator.

1.2.3 Faraday Isolator

The Faraday isolator is included in the injection seeder for two essential reasons:

1. To prevent any backward propagating radiation from the host laser from destroying the seed laser.
2. To decouple the seed laser resonator from the host resonator to preserve the frequency stability of the seed laser.

The need to decouple the two resonators to preserve the frequency stability of the NPRO imposes particularly stringent requirements for the extinction ratio of the Faraday isolator.

1.2.4 Telescope Assembly

Incorporation of a beam expanding telescope in the injection seeder helps optimize the spatial mode matching between the seed laser and the host. Spatial mode matching increases the seed laser power coupled into the fundamental mode of the host cavity. The telescope also provides a convenient adjustment to account for variable oscillator rod thermal lensing and mirror curvatures in the host laser.

1.2.5 Q-switch Build-up Time Minimization Circuit (Signal Processor)

The Q-switch build-up time minimization technique for injection seeder operations previously was discussed in Section 1.1. As mentioned, its function is to minimize the Q-switch build-up time and thereby maintain optimal frequency overlap between the seed laser and the host laser.

1.2.6 Temperature Control and Power Supply Circuits

Temperature sensitive optical elements within the injection seeder are temperature controlled to ensure consistent performance with minimal operator adjustments. Temperature stabilized components include:

1. Laser Diode - The frequency of the laser diode emission is determined by the temperature of the laser diode. Consequently, the temperature of the laser diode is set so its frequency is within the Nd:YAG absorption band.
2. NPRO Seed Laser Crystal - The output frequency of the NPRO is controlled via temperature. The temperature tuning curve has been shown in Figure 1-7.

The controller provides DC voltages for various elements, including the laser diode, the laser diode TEC, the NPRO crystal TEC, and the Q-switch build-up time minimization circuit.

1.3 HOST LASER MODIFICATIONS

Figure 1-11 provides an example of the interrelationship of the Series 101 and a Nd:YAG host laser. A description of the modifications to the host laser follows.

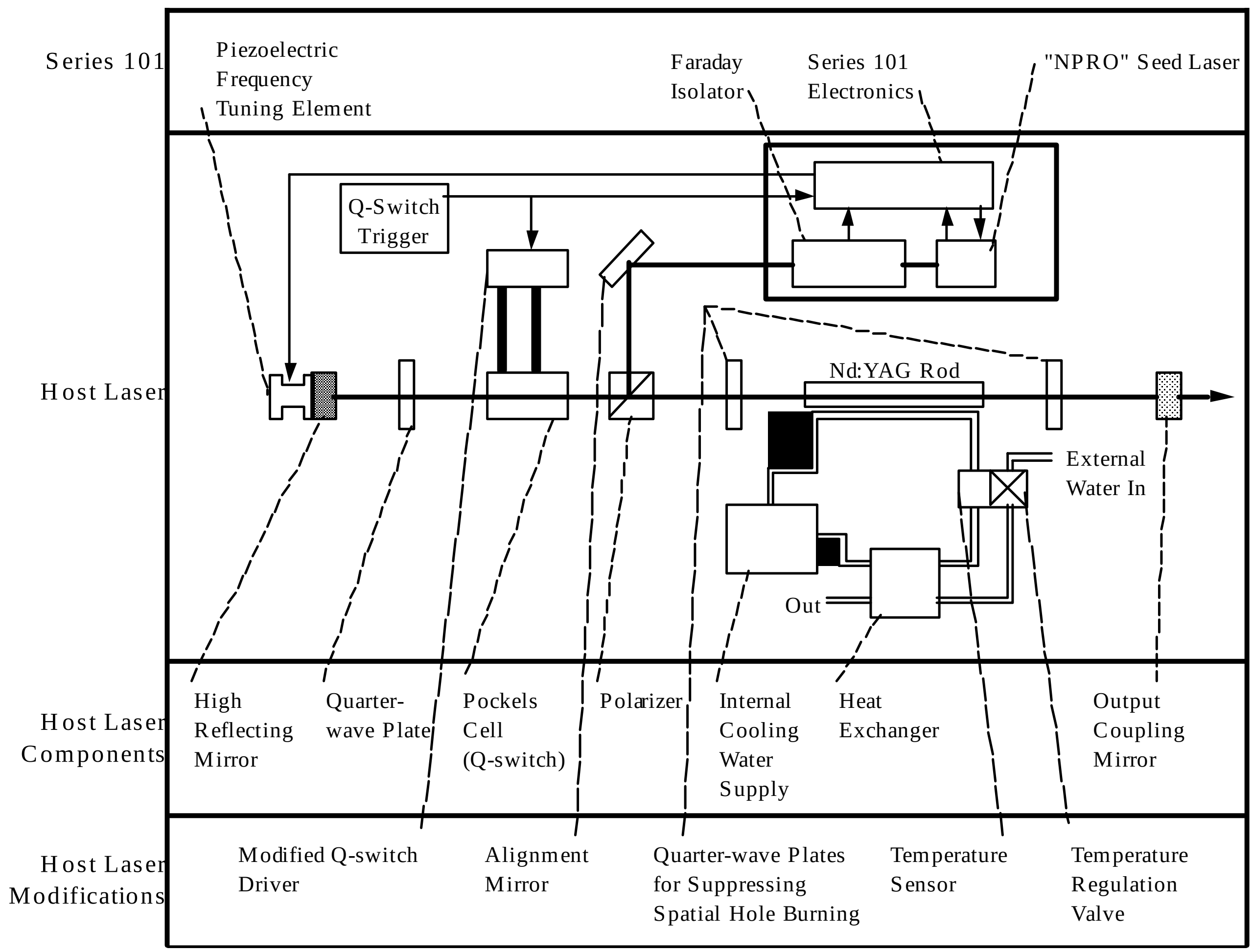


Figure 1-11: System Diagram of the Seeder/Host Laser System

1.3.1 Piezoelectric Frequency Tuning Element

Although the piezo element is included as part of the Series 101, it is actually a modification component for the host laser. The piezo is the active element which translates the high reflecting mirror of the Nd:YAG host laser to maintain optimum frequency overlap with the seed laser.

1.3.2 Quarter-wave plates

As described in the theory section, a quarter-wave plate is included on each side of the Nd:YAG oscillator rod to suppress spatial hole burning.

1.3.3 Polarizer Housing Window (not shown)

A window to allow the introduction of the seed laser beam into the host laser resonator is installed in the port in the Polarizer Housing, replacing the plug and 1.06 μm absorbing glass that normally reside there.

1.3.4 Internal Cooling Water Temperature Stabilization

A combination temperature sensor and proportional valve device should be installed in host lasers configured for injection seeding. Temperature stabilizing the internal cooling water maintains the Nd:YAG oscillator rod at the same average temperature as the NPRO seed laser, fixing its gain curve envelope in frequency. The device employed typically regulates the flow of external cooling in the host laser heat exchangers so that the internal cooling water maintains a constant temperature. Also, a pressure sensor should be included with the cooling water modification to ensure the presence of external cooling water pressure.

1.3.5 Q-Switch Drive Modification

For some host lasers it will be necessary to slow the risetime of the high voltage applied to the Pockels cell for Q-switching. The risetime for the waveform should be 30 nsec. This slow opening of the Q-switch allows a smooth pulse to build up out of the cw seed laser emission.

1.3.6 Elimination of All Secondary Etalon Effects

Special attention must be given to the installation of all optical components within the host laser resonator to ensure there are no unwanted reflections from any optical surfaces. Even the reflection from an anti-reflection coated surface, if directly on axis, is enough to form a weak etalon which can discriminate against the seed laser frequency in an indeterminate fashion. Such etalon effects can be significant enough to cause a noticeable impact on injection seeding.

1.4 LASER SAFETY

1.4.1 List of Terms

The cautions and warnings used throughout this manual are explained below. Always read and understand this information. It is basic to the safe and proper operation of the system.

WARNING: Hazardous to persons. An action or circumstance which may potentially cause personal injury or eye damage. Mechanical damage may also result.

CAUTION: Hazardous to persons or equipment. To disregard the caution may cause mechanical damage, however it is not likely to cause serious injury or death.

1.4.2 Safety Summary

Series 101 diode-pumped lasers are Class IIIb lasers as defined by the Federal Register 21 CFR 1040.10 Laser Safety Standard. The Standard requires that certain performance features and laser safety labels be provided on the product. Black and white reproductions of the warning labels are shown in this section.

Certain versions of the Series 101 may be incorporated into host lasers by the host laser manufacturer. These lasers will not comply with the Federal Register standard previously mentioned and are not intended to be removed from the host laser except for service. These Series 101 lasers will have a label clearly identifying the Series 101 laser as an OEM product, and indicating that it is exempt from CFR 1040.10.

The American National Standards Institute publishes a laser safety standard for users entitled American National Standard for the Safe Use of Lasers (ANSI Z136.1). Lightwave Corporation strongly recommends that laser users obtain and follow the procedures described in this ANSI user standard. Copies may be obtained from:

American National Standards Institute Inc.		Laser Institute of America
1430 Broadway	or	12424 Research Pkwy
New York, NY 10018		Orlando, FL 32826

WARNING: **Take extreme care when working in areas where warning and aperture labels are placed.** All apertures which can emit laser energy in excess of levels which are considered safe, or areas of the instrument to which exposure to laser radiation can occur due to disassembly, are identified with the appropriate labels shown in this section.

WARNING: **Provide protective eye wear suitable for the laser's output wavelength.** Laser output wavelength is 1064 nm or 1319 nm. Additional care should be taken if the output from the host laser will be frequency doubled, tripled, or quadrupled to ensure the protective eyewear is suitable.

1.4.3 Laser Emission Levels

The Series 101 lasers run continuous wave (CW) at 1064 nm or 1319 nm. Power will not exceed 425 mW.

Laser diode emission is contained within the laser head. A filter glass on the aperture window reduces escaping diode light to less than 1 µW. The diode emission wavelength is 800 ±15 nm.

Reproductions of the labels on the Series 101 are given in Figure 1-12.

1.4.4 Safety Features

Lightwave's Series 101 incorporates several safety features to minimize chances of damage as a result of exposure to laser emission. Locations of the safety features and labels on the laser head are given in Figure 1-13. (Controller safety feature locations are shown in Figure 2-1.)

Aperture Shutter

The aperture shutter is located on the front of the laser head and manually operated. To open the aperture and allow radiation to exit through the aperture, the shutter should be slid out. With the shutter closed an orange dot will be visible across the aperture, and laser emission will be blocked.

Key Switch

Turning the Key Switch (located on the controller front panel) to the ON position supplies electricity to the laser head and control electronics. The laser cannot emit radiation unless the key is turned to the ON position. The key cannot be removed if the switch is turned to the ON position. Simply turning the Key Switch to the ON position does not necessarily imply the laser is emitting radiation, since the laser may be in the Standby Mode or the aperture shutter may be closed.

Safety Interlock

The safety interlock is located on the rear of the laser head and allows the user to externally disable the laser for safety purposes. An example would be configuring the laser such that the interlock opens/closes when a door is opened/closed. The safety interlock is shipped with an "enable" jumper plug installed.

To utilize the interlock, remove the plug and connect switch (or relay) contacts across the input. Internally the sense circuit has a 10 ký pull-up resistor to +12 V. If the interlock circuit is open, or the input voltage is less than +7.5 V, the laser will be disabled. Once the circuit is closed, the laser will return to its previous state after a two second delay.

Emission Indicator

The emission indicator is located on the front panel of the controller and is an LED which glows yellow when the Key Switch and Control Switch are turned to the ON positions. It does not necessarily indicate the laser is emitting radiation, only that emission is possible.

Standby Mode

With the Control Switch (located on the controller front panel) turned to the STBY position, current to the laser diode is turned off and the laser cannot emit radiation. More information on the Control Switch is found in Section 2.1.2.

Warning Label - Located on the side of the right side of the laser head.

Aperture Label - Located on the front of the laser head, pointing towards the aperture.

Certification Label - Located on the front of the laser head and on the rear of the controller.

Figure 1-12: Injection Seeder Labels

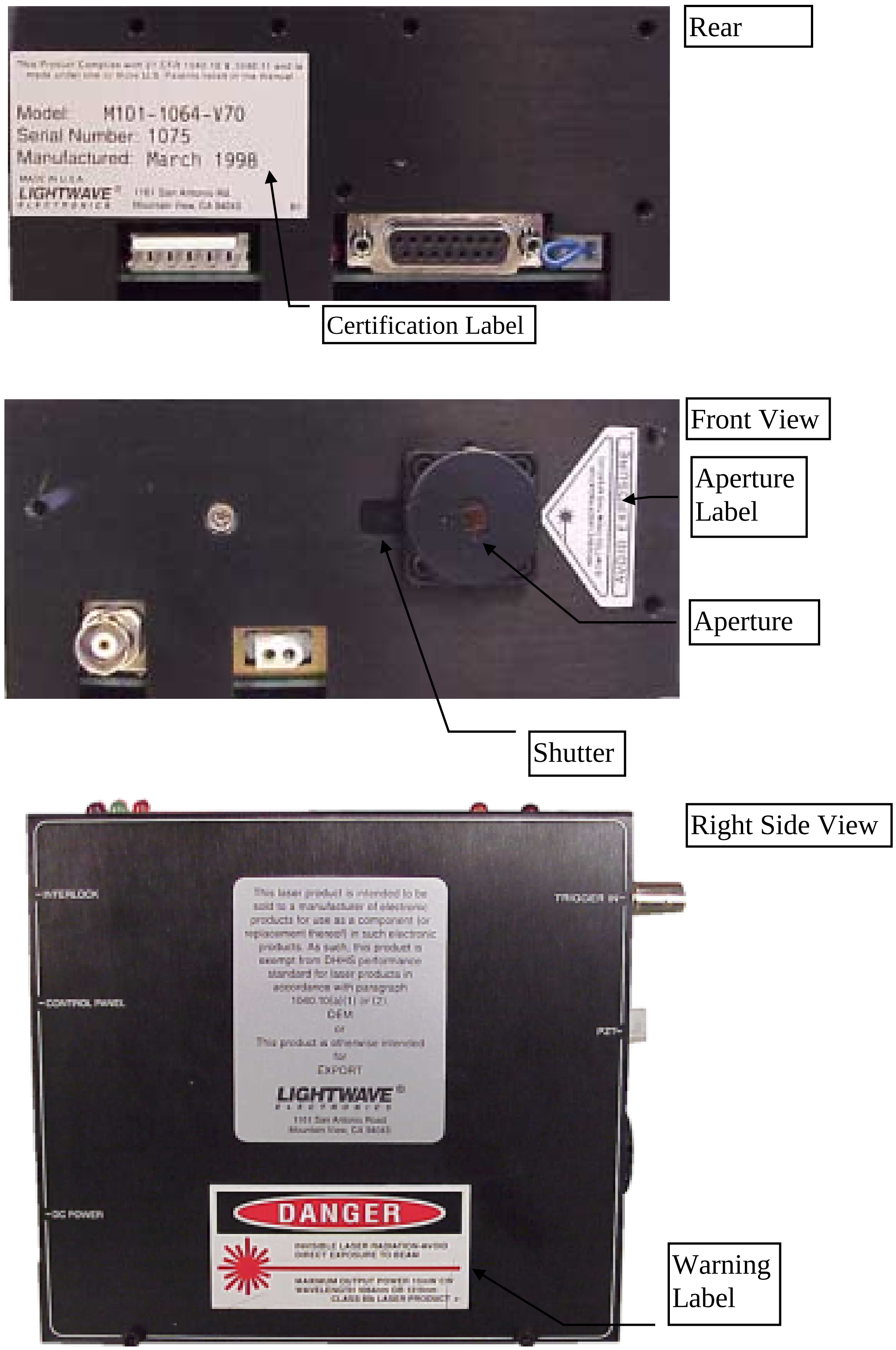


Figure 1-13: Laser Head Safety Features and Labels

SECTION 2: INSTALLATION

Proper installation of the injection seeder consists of making modifications to the host laser and then installing the seeder.

2.1 HOST LASER MODIFICATIONS

Proper preparation of the host laser is essential for good seeder operation. Prior to making the necessary host laser modifications, the host laser must be operating properly.

An overview of the modifications necessary for injection seeding are shown below in Figure 2-1. Modifications include adding and/or modifying the Marx bank, stabilizing the Nd:YAG cooling water temperature, attaching the piezo element to the high reflecting end mirror, adding additional quarterwave waveplates, providing superior vibration isolation, and modifying the polarizer assembly. These modifications are discussed in the following sections.

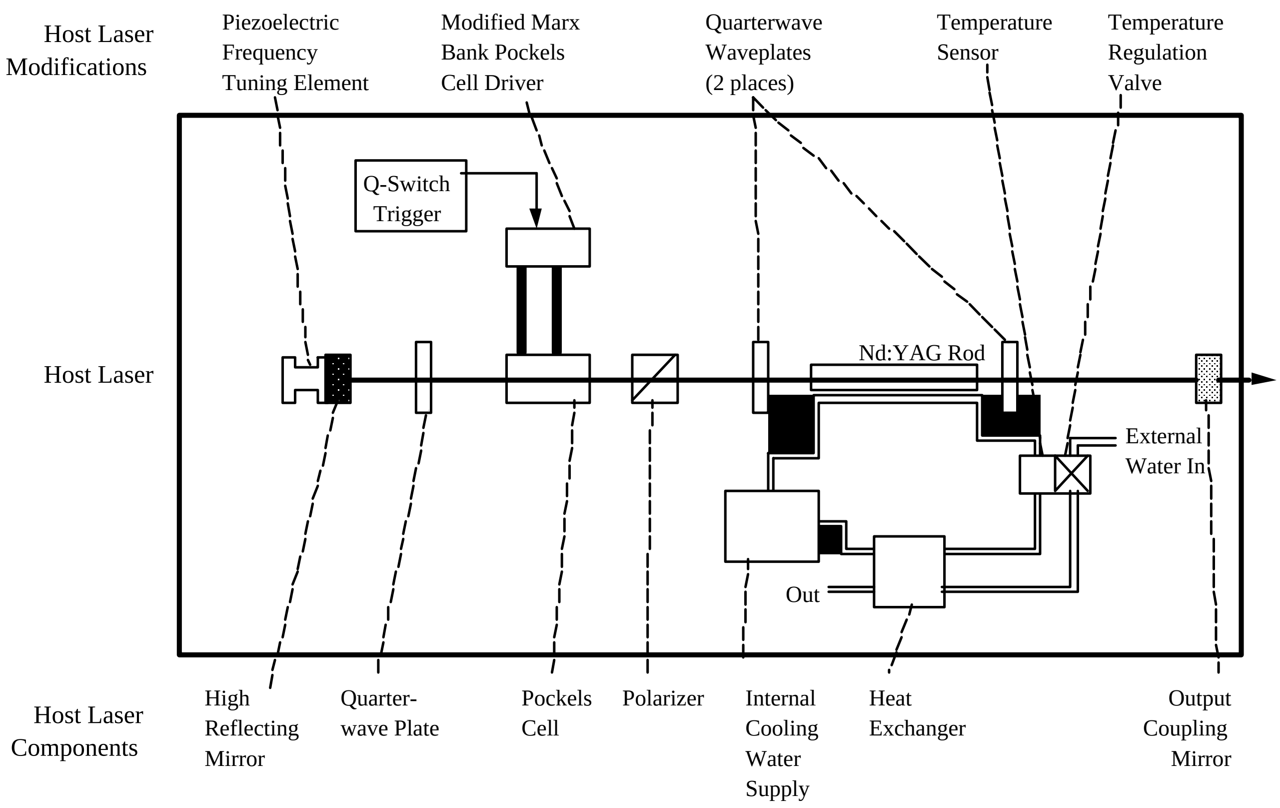


Figure 2-1: Typical Host Laser Modifications

2.1.1 Marx Bank

If the host laser does not have a Marx bank for the Q-switch, one should be installed before proceeding.

For injection seeding, the rise time of the waveform should be approximately 30 ns.

2.1.2 Cooling Water Stabilization

The cooling system should be modified to include a regulator such that the temperature of the Nd:YAG rods is stabilized to within ±1°C.

A typical configuration for achieving this is shown below in Figure 2-2.

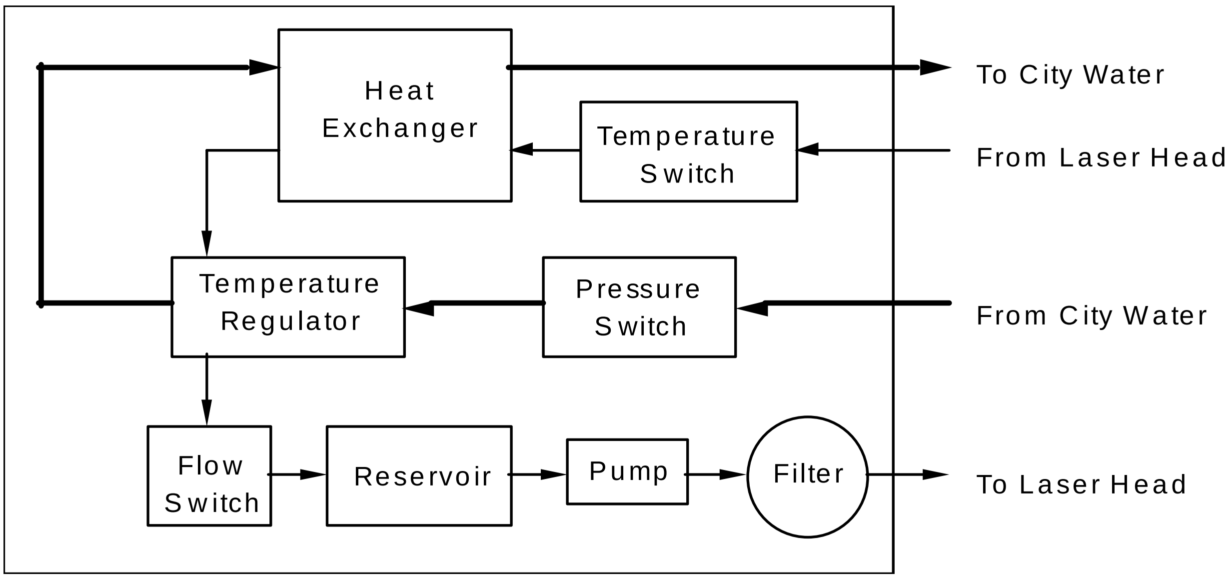


Figure 2-2: Typical Cooling Water Configuration

Note that the water reservoir should be kept at least >75% full. The water in the reservoir acts as a large thermal mass, damping any rapid changes in the circulating water temperature. This improves the temperature control of the circulating water and thus improves seeding stability.

2.1.3 Vibration Isolation

Isolating the host resonator from vibration sources is very important for achieving consistent single mode operation. All electrical components (such as SCRs, inductors, etc.) that produce vibration should either be removed from the laser head area or mounted on damping material.

In particular, many lasers incorporate a fan to keep the laser head's temperature fairly evenly distributed. Such a fan should be remounted on a shock mount.

2.1.4 Polarizer Assembly Modifications

The seed laser beam is usually injected into the host resonator through the polarizer assembly next to the Q-switch. In most cases this will require the polarizer to be modified. A procedure for modifying a typical polarizer assembly and a sketch of a typical assembly are given below.

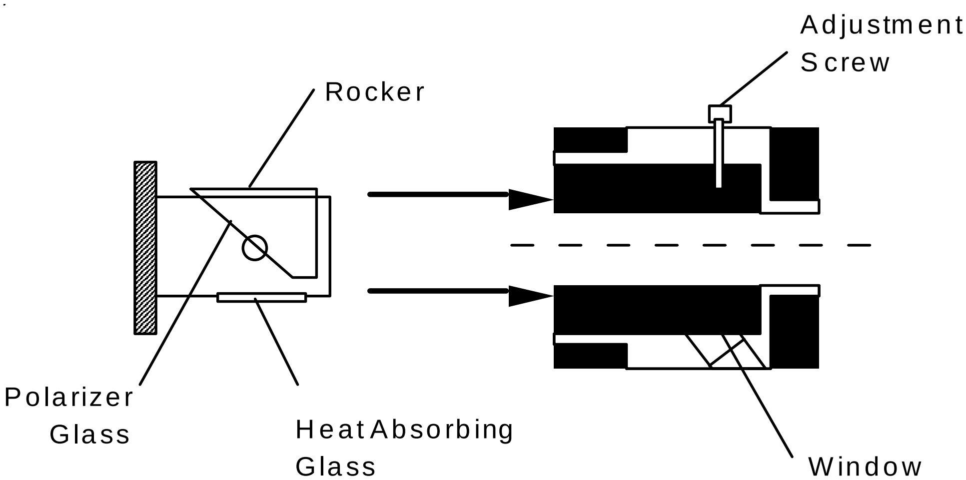


Figure 2-3: Polarizer Assembly Modifications

1. Remove the dust tube between the polarizer and the host laser pump chamber.
2. Remove the entire polarizer assembly housing.
3. Disassemble the polarizer assembly housing.
4. Remove the heat absorbing glass by pulling it out of its slot or knocking it loose. The glass may break, but this is okay.
5. Install the window assembly in the housing.
6. Reassemble the polarizer assembly.

7. Reinstall the polarizer assembly in its mount, taking care to return the polarizer to its original orientation.
8. Verify that these changes did not affect the host laser's performance by operating the host laser at its set power and measuring the power output.

2.1.5 Quarterwave Waveplate Installation

Quarterwave waveplates should be added to each side of the Nd:YAG rod to produce a "twisted mode" in the rod. Typically, one waveplate is added in the polarizer mount and the other in the output coupler mount. A typical procedure for adding the waveplates follows.

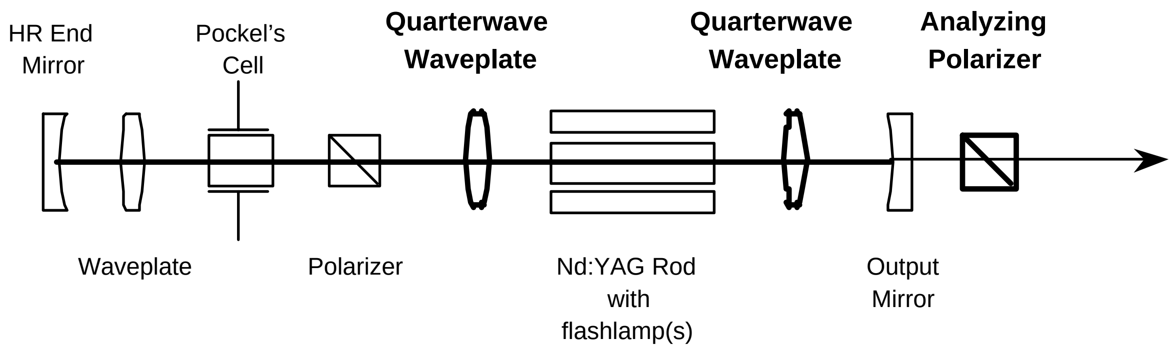


Figure 2-4: Quarterwave Waveplate Additions

1. Insert an analyzing polarizer and a power meter in the host laser's output beam path.
2. Set the host laser in the long-pulse mode.
3. Orient the analyzing polarizer about the beam axis to pass vertically polarized light. Initially place the polarizer to have a high angle of incidence (polarizer has slope near zero). With the laser running at the desired operating level, decrease the angle of incidence until the power peaks and then falls approximately 5%. This ensures that the polarizer will extinguish horizontally polarized light.
4. Remove any host laser cavity dust tubes.
5. Insert one of the quarterwave waveplates. Rotate the waveplate for minimum power meter reading or extinction of lasing. Check all four minimum positions for the absolute minimum reading. Secure the waveplate.
6. Insert the other quarterwave waveplate. Rotate the waveplate for maximum power meter reading. Check all four maximum positions for the absolute maximum reading. Secure the waveplate.
7. Reinstall the host cavity dust tubes, being careful not to disturb the waveplates.
8. Check the resonator alignment, holdoff, and power. Make adjustments to the Q-switch voltage and cavity alignment as necessary, but do not readjust the quarterwave waveplates.

2.1.6 Piezo Installation

A piezoelectric element is supplied with the seeder, and this piezo should be attached to the rear reflector of the host laser to control its length (frequency). The piezo assembly as supplied by Lightwave is shown below in Figure 2-5 (Lightwave does not supply the HR end mirror). A typical procedure for installing the piezo is given below.

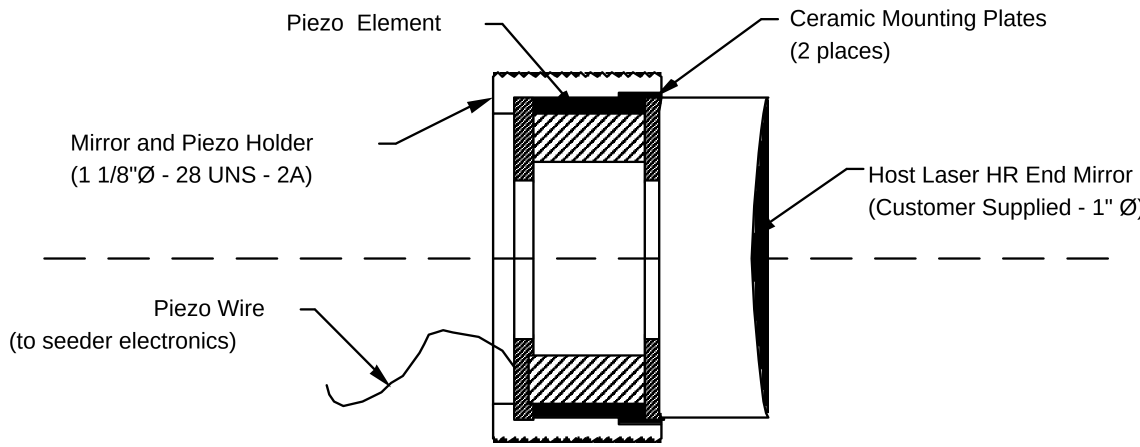


Figure 2-5: Piezo Assembly

1. Remove the high reflecting (HR) mirror from its mount by unscrewing the endcap and pulling the HR mirror out.
2. Glue the HR End Mirror to the Ceramic Mounting Plate which is away from the piezo wire. Ensure the mirror is well centered on the ceramic plate and does not extend beyond the edges of the ceramic plate.

3. Place the Piezo Element (with HR end mirror attached) into the Mirror and Piezo Holder. Ensure there is no interference between the HR End Mirror and Mirror and Piezo Holder.
4. Install the Mirror and Piezo Holder (with Piezo Element and HR End Mirror) in the host laser.
5. Route the Piezo Wire to the seeder's laser head, and plug it into the "PZT" input.
6. Realign the resonator as appropriate. Normally it is not necessary (nor desirable) to adjust the output coupled mirror.
7. With the host laser running at its standard operating energy, optimize the alignment by adjusting only the HR End Mirror.

2.2 SEEDER INSTALLATION

Proper preparation of the host laser is essential for good seeder operation. Prior to making the necessary seeder modifications, the host laser must be operating properly (see Section 2.1).

It may be necessary to refer to Section 3 to understand how to turn on/off the seeder and other seeder functions before proceeding with this section.

2.2.1 Mounting

A typical host /seeder configuration is shown in Figure 2-6. A set-up procedure follows.

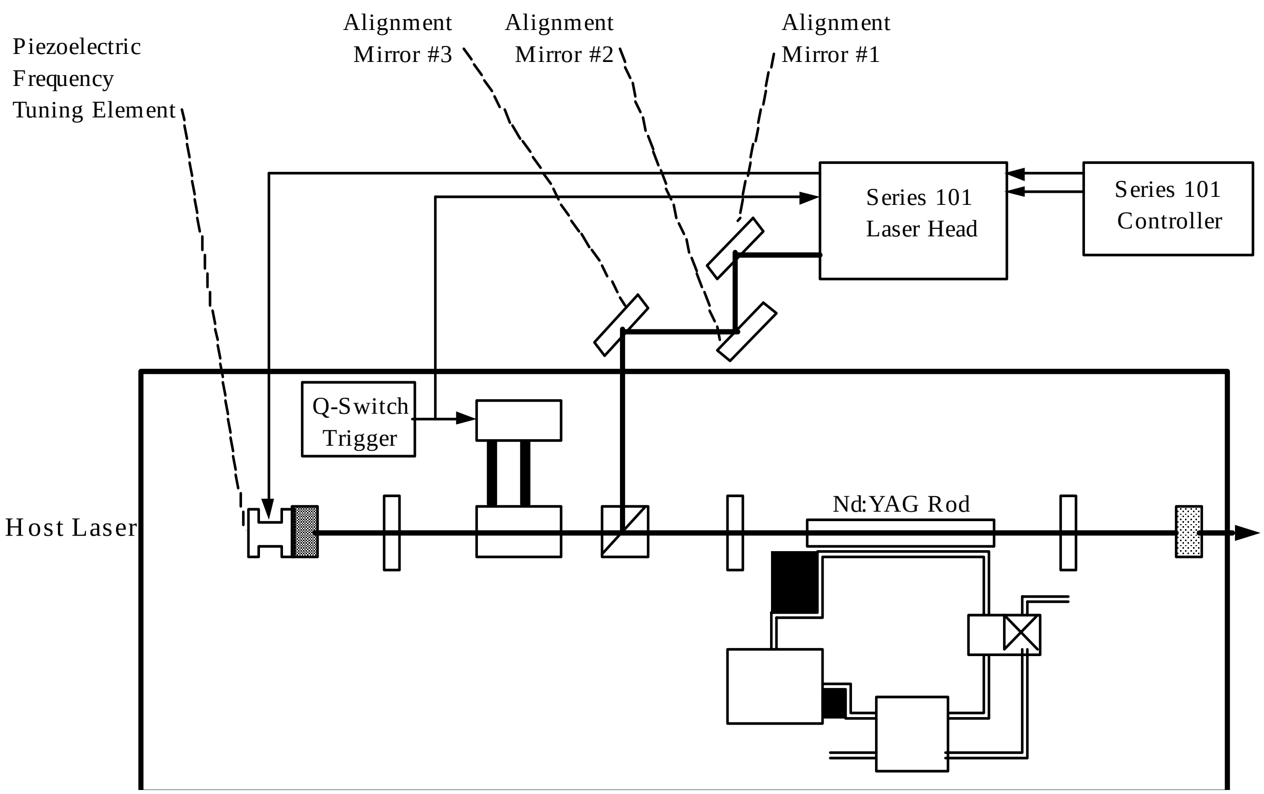


Figure 2-6: Typical Injection Seeder Installation Configuration

1. Solidly attach the Series 101 laser head to the same baseplate that supports the optical elements of the host laser cavity.
2. Attach appropriate turning mirrors to direct emission from the seed laser into the host cavity (through the polarizer assembly). Using at least 2 alignment mirrors is a good idea since it provides sufficient degrees of freedom for alignment of the seed laser beam with the host cavity without requiring the laser head to be moved.
3. Plug the Series 101 controller into an available wall outlet. The Series 101 controller will accept any AC voltage from 85 to 265 VAC, 50 to 400 Hz.
4. Attach the umbilical cord from the rear of the Series 101 controller to the rear of the Series 101 laser head.

5. Plug the piezo element's lead into the connector on the front of the Series 101 laser head labeled "PZT".
6. Split the signal from the Q-switch trigger source and route this signal to the BNC connector on the front of the Series 101 laser head labeled "TRIGGER IN".

2.2.2 Gross Mirror Alignment

All seeder/host laser systems require some beam steering mirrors to manipulate the seed beam into the host cavity and make the host and seed beams colinear at the output of the host laser. By centering the seeder output on the host laser output using the turning mirrors, and then fine tuning the turning mirrors to minimize the Q-switch build-up time, the spatial overlap can be optimized. A procedure for centering the seeder output on the host laser output is outlined below and assumes the three mirror system shown in Figure 2-6. Optimization is discussed in Section 2.2.5.

1. Turn the host laser to low energy, long pulse operation.
2. Turn the Control Switch and Key Switch on the injection seeder to ON. The emission indicator light should turn on. Confirm that there is output at the seeder with an IR card.
3. Using an IR card or viewer, determine if the seed beam exists at the output of the host laser. If it does exist, proceed to Step 6.
4. If the seed beam does not exist at the output, check that the seed beam and host beam are overlapped (colinear) between mirrors #1 and #2.
   a. Turn on the host laser flashlamps and adjust the power such that the host laser is just above threshold.
   b. With the IR card just before mirror #2 and facing the seeder, check to see if the seed beam is centered on the host beam. If not, use mirror #1 to steer the seed beam as required.
   c. With the IR card just in front of mirror #1 and facing the host laser, check to see if the host beam is centered on the seed beam. If not, use mirror #2 to steer the host beam as required.
5. With the host laser off, the faint seed beam should now be observable at the output of the host laser. If not, repeat step 4.
6. Using an IR card or viewer, alternately observe the seed beam and host laser beam. Adjust mirrors #1 and #2 until the seed beam is centered on the output coupler. Make adjusts in small increments so as not to completely loose the seed beam.

2.2.3 Q-switch Voltage Optimization

The Marx bank voltage is optimized by the following procedure.

CAUTION: Gross misadjustment of the Q-switch voltage can cause excessive power to be returned to the seeder causing damage to the Faraday isolator and/or laser. Such damage is excluded explicitly from Lightwave's warranty. Return energy must be kept <10 mJ/pulse.

1. Place a power meter between mirrors #2 and #3.

2. Turn on the host laser to normal Q-switch operation.
3. Record the output energy of the host laser.
4. Adjust the Marx bank voltage to minimize the feedback from the host laser.
5. If the energy is >10 mJ/pulse after minimizing feedback, turn off the laser system. Contact the host laser manufacturer or otherwise modify the Marx bank such that the feedback is <10 mJ/pulse. **DO NOT PROCEED.**
6. Remove the power meter from the optical train.
7. Verify seeder performance by observing the Q-switched build-up reduction time.
8. Turn the seed and host lasers off.

2.2.4 Frequency Overlap Adjustment

The overlap of the seed laser frequency and the host laser frequency is critical for efficient, consistent injection seeding. There are two procedures for optimizing frequency overlap. The first method is for customers with a 2nd harmonic generator and a Fabry-Perot etalon. The second method only requires a chart recorder, but the first method is considerably easier and more effective. Before beginning, ensure the seed and host beams are properly overlapped, as described in Section 2.2.2.

Method 1: Using 2nd harmonic generator and Fabry-Perot etalon

1. Configure the host laser for second harmonic generation.
2. Turn on the host laser to Q-switched mode. Ensure that the host laser is sufficiently warmed-up to the extent that external cooling water is flowing. Thus, the gain center frequency of the host Nd:YAG oscillator rod should be stabilized and fixed.
3. Send the 1.06 µm radiation into a beam dump and route the 532nm radiation through a 3cm^{-1}, 0.5 µm Fabry-Perot etalon, as shown in Figure 2-7. Arrange these elements such that the etalon rings can be observed on a screen while adjustments are made on the seeder assembly. The harmonic generator can be detuned to ensure that a safe level of 532 nm power is incident on the etalon. See Section 3.4.2 for an example of the output through the etalon.

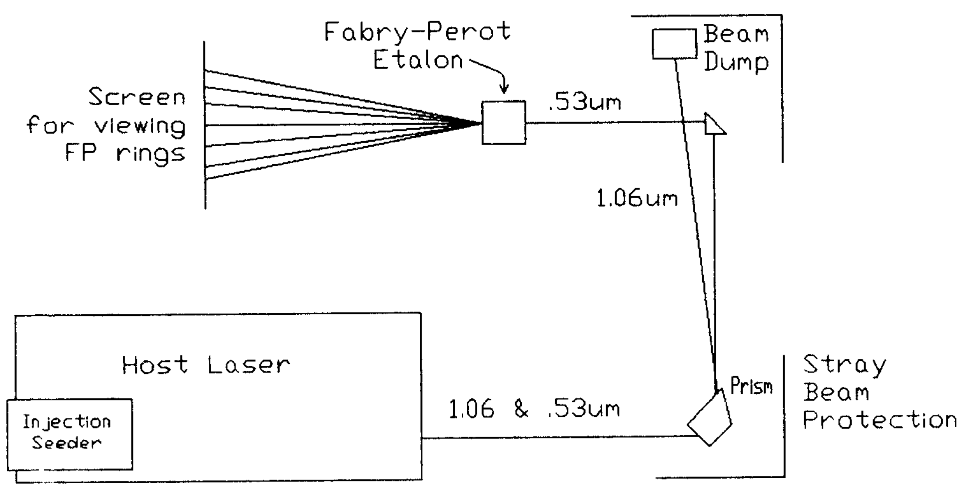


Figure 2-7: Optical Layout For Observing Frequency Overlap

4. Set the seeder Mode Switch to AUTO. LED 2 (green) on the seeder control PCB should flash at one-half the laser repetition rate of the host laser. Use a business card (or like) to block and unblock the seed laser beam before the Faraday isolator.
5. With the seed laser beam blocked, the etalon fringes should appear very wide and somewhat indistinct. When the seed laser beam is introduced, the fringes should constrict noticeably and become more distinct. Good frequency overlap is evident when the unseeded broad fringes constrict symmetrically to the distinct seeded fringes. This is checked by repetitively blocking and unblocking the seed beam and watching the fringes. Typically it is necessary to adjust the seed laser temperature/frequency potentiometer to center the seeded fringes in the unseeded fringes. As the seed laser frequency is adjusted through its range, the etalon fringes periodically will jump. These jumps in the etalon fringes correspond to mode hops, as described in Section 1.1.6 and 1.1.7. They occur approximately every 20 GHz in the 1.06 µm seed laser (40 GHz @ 532 nm). It is important to run the seed laser at a frequency roughly centered between mode hops.
6. As a check, optimal frequency overlap will correspond to minimum loss in 1.06 µm power when the host laser is taken from the unseeded to the seeded condition. Check this by removing any doubling crystal from the beam path and sending the 1.06 µm beam into a power meter. When the seed laser beam is blocked there should be little or no increase in power on the power meter.

Method 2: Using a chart recorder

1. Turn on the host laser to Q-switched mode. Ensure that the host laser is sufficiently warmed-up to the extent that external cooling water is flowing. Thus, the gain center frequency of the host Nd:YAG oscillator rod should be stabilized and fixed.
2. Set the seeder Mode Switch to AUTO. LED 2 (green) on the seeder control PCB should flash at one-half the laser repetition rate of the host laser. Use a business card (or like) to block and unblock the seed laser beam between the seed laser and the isolator.
3. Connect a chart recorder to the Q-switch Build-Up Time BNC. To set the proper voltage range on the chart recorder, use a business card (or like) to block and unblock the seeder beam before the Faraday isolator. See Section 3.1.7 for additional information on the Build-Up Time BNC.
4. Slowly adjust the laser frequency as the chart records the build-up time.
5. Select the point that has the lowest minimum build-up time.

2.2.5 Fine Mirror Alignment

1. Turn the host laser to low energy, long pulse operation.
2. Turn the Control Switch and Key Switch on the injection seeder to ON. The emission indicator light should turn on. Confirm that there is output at the seeder with an IR card.
3. Using an IR card or viewer, alternately observe the seed beam and host laser beam. Adjust mirrors #1 and #2 until the seed beam is centered on the output coupler. Make adjusts in small increments so as not to completely loose the seed beam., If the seed beam is not visible return to Section 2..
4. Switch the host laser to normal, short pulse, full energy Q-switch operation.
5. Using an oscilloscope, observe the Q-switch build-up reduction time as described in Section 3.4. Allow the host laser at least 30 minutes of operation at normal temperatures before proceeding.
6. Maximize the Q-switched build-up reduction time by adjusting mirrors #1 and #2. Since the host and seed beams should overlap, the mirrors should not require substantial realignment.

SECTION 3: OPERATION

3.1 CONTROL PANEL

The key operational procedures in the use of the injection seeding system involve the controller's front panel (control panel). The control panel is shown in Figure 3-1, while descriptions of the various features follow.

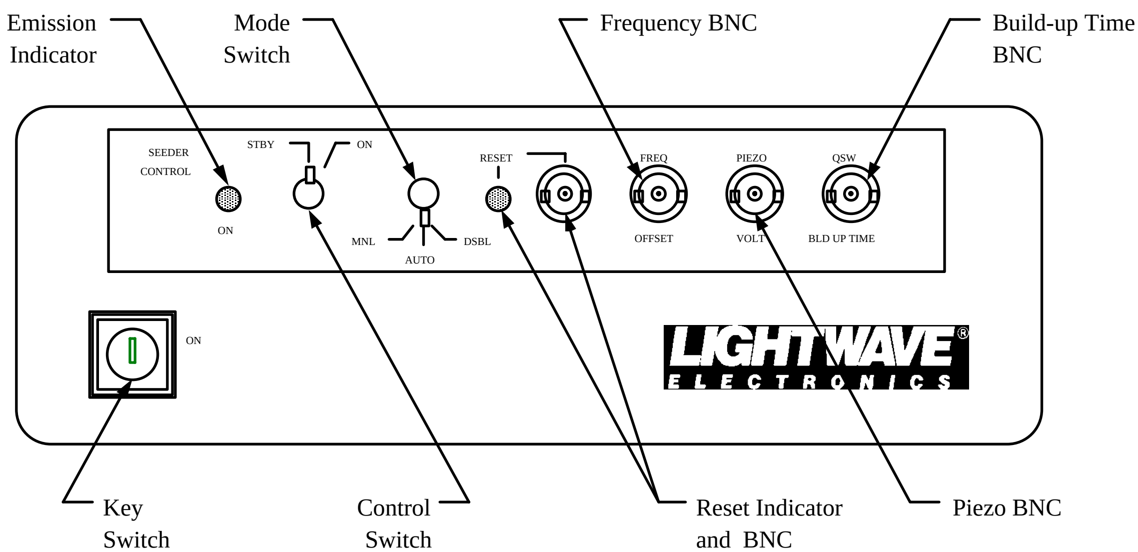


Figure 3-1: Control Panel of Controller

3.1.1 Key Switch

The Key Switch should be turned to the ON position in order to supply electricity to the seed laser's head and control electronics. The seed laser cannot emit radiation unless the key is turned to the ON position. Turning the Key Switch to the ON position does not necessarily imply the laser is emitting radiation, since the laser may be in the Standby Mode or the aperture shutter may be closed. There is a 15 second delay between turning the key switch to "ON" and any possible emission.

3.1.2 Emission Indicator

The amber emission indicator is illuminated whenever the Control Switch and the Key Switch are turned to the ON position, and the interlock is closed. After turn-on there is a 3 second delay before the seed laser emits light.

3.1.3 Control Switch

With the Control Switch in the STANDBY ("STBY") position all temperature control circuits are operational, but the current to the laser diode is turned off (i.e. the seeder is not lasing). In the ON position the laser is fully operational. There is a 3 second delay between switching to "ON" and laser emission.

3.1.4 Mode Switch

The Mode Switch is a three position switch which controls the servo reset system.

MANUAL (MNL) The build-up time reduction control circuit is not active. The piezoelectic voltage is reset and held at the center of its range.

AUTO The build-up time reduction control circuit is active. The servo reset system automatically resets to the center of the piezoelectric voltage range whenever the piezo voltage nears the end of its range.

DISABLE (DSBL) The build-up time reduction control circuit is active, but the piezo does not automatically reset when it reaches the end of its range. Consequently, if the voltage to the piezo is at its limit, the build-up time reduction circuit will not function properly.

As described in Section 1.1.4, the piezo's voltage range is from -400 V to +400 V, with ^{3}0 V being the reset value. When the Mode Switch is set to AUTO the piezo automatically resets to 0 volts whenever the piezo voltage has scanned to within 50 volts of a limit (ie. ±350 volts). If a long experimental data run is being taken and it is noted that the piezo voltage is nearing the end of its range, the AUTO reset can be disabled allowing the piezo to go to the full extent of its range (±400V) by placing the Mode Switch in the DISABLE position.

3.1.5 Reset Indicator

This yellow LED is illuminated when the servo reset system is automatically resetting the piezo to zero volts.

3.1.6 Reset BNC

This connector provides a low signal output during AUTO reset when the piezo has scanned to a limit of its range and is being reset. The output is of the "open collector" type, meaning that it can sink up to 250mA when in the low state.

This can be used to blank experimental data capture during the reset time over which the servo electronics are reacquiring a "locked" condition (approximately 15 sec).

3.1.7 Frequency BNC

The frequency of the seed laser can be adjusted by applying a voltage to this BNC. Since good overlap of the seed laser and host laser frequencies is necessary for proper seeding, if the seed laser frequency is adjusted it also may be necessary to adjust the host laser frequency (via the Nd:YAG rod cooling water temperature). The seeder's frequency is adjusted by applying an analog voltage to this BNC, ranging from -10 V to +10V. This corresponds to approximately a ±10 GHz tuning range.

3.1.8 Piezo BNC

The Piezo BNC provides a voltage ranging from -4 to +4 volts, proportional to 1/100th the voltage applied to the piezo. The center of the piezo range is equivalent to 0 volts. Thus, -400, 0 and +400 volts on the piezoelectric element corresponds to -4, 0, and 4 volts, respectively, at the Piezo BNC output.

This output can provide information concerning dither magnitude, rate of host laser frequency drift, where the piezoelectric voltage is within its range, etc.

3.1.9 Build-Up Time BNC

This connector provides an output voltage ranging from 0 to 8 volts, proportional to the Q-switch build-up time.

3.2 LASER HEAD CONTROL PANEL

In addition to the controls on the controller, several additional diagnostics and parameter adjustments exist on the seeder's laser head. A schematic of the top of the laser head is shown below, and descriptions of the features follows.

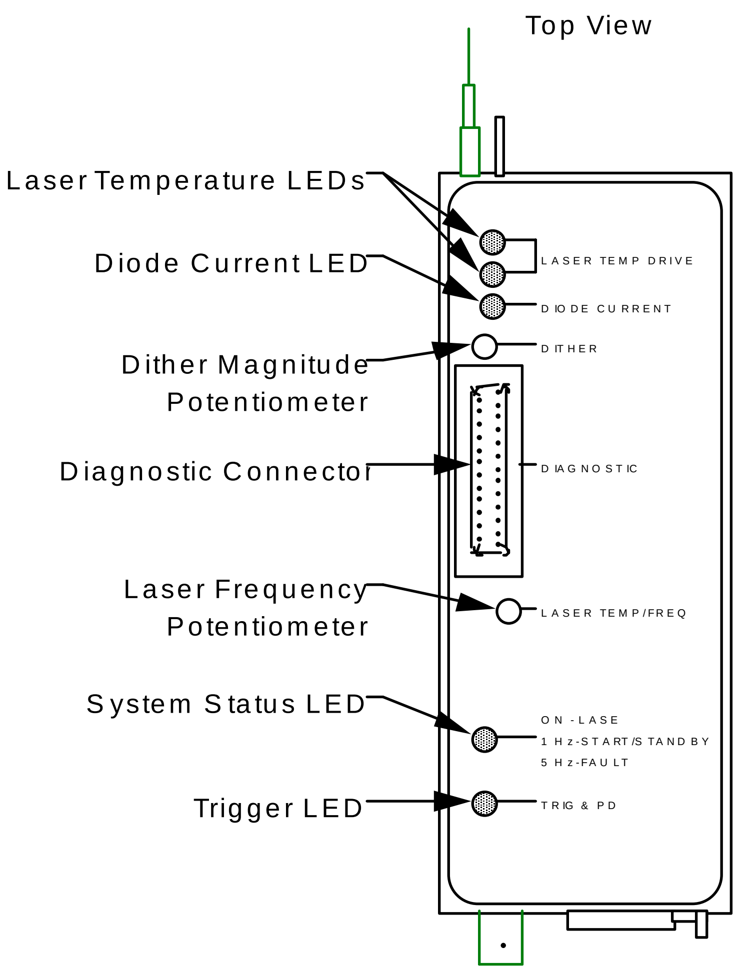


Figure 3-2: Laser Head Top View

3.2.1 Laser Temperature LEDs

These two LEDs indicate the status of the TEC under the laser crystal. The red LED indicates the TEC is heating, while the green LED indicates it is cooling. When the laser is initially turned on, one of these lights may be very bright as the crystal temperature stabilizes. After the crystal temperature stabilizes both LEDs should be on, although the intensities of the two LEDs will be different in most cases.

3.2.2 Diode Current LED

This LED indicates that current is flowing to the diode, and that the diode should be on. Unlike the emission indicator, the Diode Current LED indicates that the seeder is lasing. There should be laser emission unless the aperture shutter is closed.

3.2.3 Dither Potentiometer

This potentiometer sets the dither magnitude of the piezo in the host laser. Turning the potentiometer clockwise will increase the dither magnitude.

3.2.4 Diagnostic Connector

The optional Lightwave Electronics Diagnostic Box attaches at this connector.

3.2.5 Laser Frequency Potentiometer

Turning this potentiometer will alter the temperature of the laser crystal, and consequently the seed laser's frequency. The crystal temperature range is from ³20°C to ³60°C. Turning the potentiometer clockwise increases the crystal's temperature, and decreases the laser's frequency. As discussed in Section 2.1.7, adjusting the frequency of the seed laser may require adjusting the temperature of the host laser's cooling water.

3.2.6 System Status LED

As indicated on the top of the laser head, this LED will be on when the laser is lasing, will flash at a 1 Hz rate when the laser is in Standby Mode, and will flash at 5 Hz when there is a fault.

3.2.7 Trigger and Photodiode LED

This LED should flash at half the host laser's pulse repetition rate. If this is not happening, either the Q-switch trigger input into the seeder's locking electronics is faulty or missing, or the photodiode in the seeder is not "seeing" the pulse which is rejected back to the seeder.

3.3 SYSTEM START UP

1. Turn on the host laser. Turn the injection seeder Control Switch to STANDBY. With the host laser Q-switch mode in OFF, or EXTERNAL, turn the lamp power for both the oscillator and amplifier (if applicable) up to their desired operating levels. Allow the host laser to warm up for 20 minutes or until external cooling water is flowing.
2. Turn the Control Switch to ON.
3. Set the Mode Switch to AUTO.
4. Connect a voltmeter to the Build-Up Time BNC. A fast oscilloscope and a fast detector (response time <1 ns) also can be used to observe laser scatter and determine the Q-switch build-up time.
5. Observe the Q-switch build-up time voltage with the voltmeter or the Q-switch build-up time on an oscilloscope. The build-up time reduction can be observed by changing the Control Switch from ON to STANDBY. Allow 30 seconds for the seeder to stabilize when switching from ON to STANDBY. If the Q-switch build-up time is not normal (see Section 1), see procedures for adjusting the mirror alignment in Section 3.

3.4 SYSTEM CHECK

Proper seeding of the host laser can be checked by observing the output pulses on an oscilloscope and/or the output through an etalon. Observing the output pulses on an oscilloscope generally provides better information, and normally it is unnecessary to check with an etalon.

3.4.1 Pulse Trace Observation

Figure 3-3 shows the temporal profile of laser pulses from a seeded and unseeded host laser.

Because the oscilloscope was triggered off the laser pulse, the pictures do not show the pulse-to-pulse timing jitter or the change in pulse build-up time. If the oscilloscope were triggered off the Q-switch trigger signal rather than the laser pulse, additional information regarding the timing of the pulses would be available. In such a case, the pulse should arrive about one pulse width (approximately 10 nsec) sooner when seeded. Since the locking electronics monitor the pulse build-up time, it is recommended that the oscilloscope be triggered off the Q-switch trigger rather than the output pulses to determine how well the system is locking.

3.4.2 Output Through an Etalon

Figure 3-4 demonstrates the characteristic linewidth and stability of a seeded versus unseeded system. They are both 60 second exposures of a doubled output (532 nm) 20 Hz YAG laser through a 0.25 cm^{-1} etalon. As previously mentioned, it is not necessary to check the output through an etalon to confirm proper operation. Rather, this test is for double-checking performance. An explanation of how to set up the etalon is given in Section 4.3.3.

3.5 SYSTEM SHUTDOWN

1. Return the host laser oscillator and amplifier power to their lowest level.
2. Turn the injection seeder Control Switch to STANDBY.
3. Turn the host laser OFF.

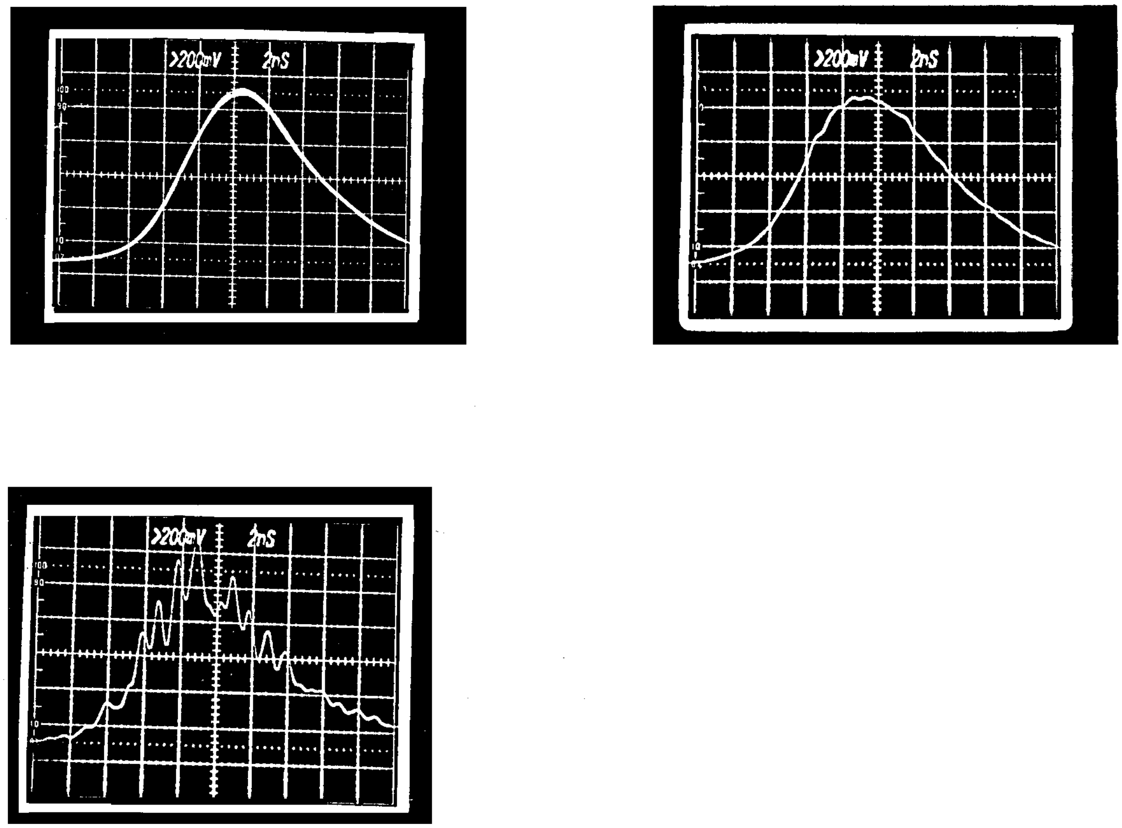


Figure 3-3: Temporal Profile of Seeded and Unseeded Pulses

The top left picture is an oscilloscope trace of 200 pulses emitted from an injection-seeded host laser. The top right picture is a single injection-seeded pulse. The bottom left picture is a single, unseeded pulse. These temporal profile photos were taken using a Tektronix 7104 (1GHz) oscilloscope and a Hamamatsu planar photodiode.

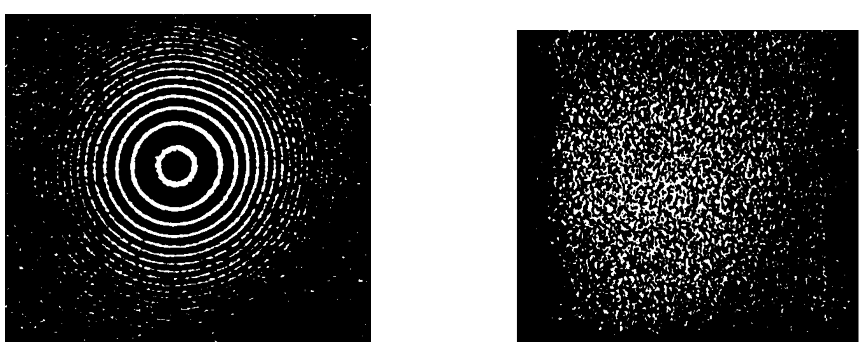


Figure 3-4: Output through an Etalon

The left picture is the output for a seeded laser, while the picture on the right is for an unseeded laser.

SECTION 4: MAINTENANCE

The following sections discuss seeder and host laser service which can be performed in the field if the system is not performing properly.

4.1 HOST LASER MAINTENANCE

The injection seeder assembly is factory aligned and adjusted. There are no parts within the injection seeder requiring routine maintenance. When used in conjunction with the injection seeder, however, the host laser requires special attention beyond that required for non-seeded operation. Specifically, the following items should be monitored periodically and attended to if necessary.

1. It is important to monitor the power rejected off the host polarizer which is incident on the injection seeder. This is especially true if the ambient temperature around the seeder/host laser system changes significantly (>10°C) from the temperature during installation. Power is rejected off the host polarizer for two reasons:

    a. The Pockels cell does not give a perfect, uniform, quarter-wave phase retardation across the entire beam diameter at the exact time that the pulse is being emitted from the host. A typical reason for this is the Pockels cell quarter-wave voltage is a function of temperature, changing by approximately 50 V/°C.
    As a result, if the ambient operating temperature changes significantly from the initial installation temperature, the Pockels cell voltage must be adjusted to prevent an excessive amount of energy from being directed back towards the injection seeder. The procedure for making this adjustment is in Section 2.2.3.
    The Pockels cell also can give a non-quarter-wave phase retardation due to the inherent difficulties in applying a uniform high voltage across the entire aperture of the crystal within the Pockels cell. This, however, should not change over time provided the Pockels cell is properly aligned and in good working condition.

    b. The host laser's polarizer angle has shifted. This may occur due to changes in temperature and/or humidity. If the shift in angle causes the polarizer to reject a significant amount of "p" (vertical) polarization, then a certain fraction of the circulating power within the host resonator will be rejected off the host polarizer in the direction of the injection seeder. If such a shift in angle occurs, it should be corrected.

2. The water reservoir should be kept at least >75% full. The water in the reservoir acts as a large thermal mass, damping any rapid changes in the circulating water temperature. This improves the temperature control of the circulating water and thus improves seeding stability.

3. A strong holdoff condition must be maintained in the host laser. The stability of seeding is greatly impaired by inadequate holdoff. Operating the laser system with insufficient holdoff can lead to damage in both the injection seeder and the host laser. A periodic check of the holdoff condition can help prevent this from becoming a problem.

4.2 SEEDER/HOST SYSTEM SERVICE

Any service concerning the host laser optics should be performed with an awareness of the potential impact on the injection seeder and the injection seeding process. Common examples are given below.

- Changing the host laser's Nd:YAG rod requires checking the frequency overlap between the seed and host lasers. Also, the new rod will have different focusing characteristics, and this will warrant a check of the spatial mode overlap.
- Changing the polarizer may require realigning turning mirrors. See Section 2.
- Changing the Pockels cell would necessitate a check of the Pockels cell voltage.
- Changing or realigning the Pockels cell, polarizer, or Nd:YAG rod requires realigning the quarterwave waveplates around the Nd:YAG rods.

These are just a few examples which illustrate the coupling of the seeder and the host laser. A general awareness of how changes in the host optics can impact injection seeding combined with an appropriate execution of the necessary checks/adjustments should suffice to keep the host laser and the injection seeder working well together.

SECTION 5: TROUBLESHOOTING

SYMPTOM #1: Electronics Do Not Lock

POSSIBLE CAUSE:
Piezoelectric element disabled.
REMEDY:
Verify that the Mode Switch is in AUTO. Check piezoelectric connection and installation in high reflecting mirror mount.

POSSIBLE CAUSE:
Q-switch BUT circuit not receiving proper signals: Trigger and Photodiode LED does not flash at 1/2 the host repetition rate.
REMEDY:
Check Q-switch trigger signal into seeder. Check photodiode pulse at pin 6 of the Diagnostic Connector (located on the top of the laser head). Signal at pin 6 should go high (5V) to low and stay low for >1.0 µsec, thus indicating that the photodiode has received enough light to be well saturated. If pin 6 does not stay low, check the spatial mode overlap and photodiode alignment.

SYMPTOM #2: Excessive Power Drop in 1.06 µm Pulse Output when Seeded.

POSSIBLE CAUSE:
Frequency overlap not optimal.
REMEDY: See Section 2.2.4

POSSIBLE CAUSE:
Excessive spatial hole burning in host oscillator.
REMEDY:
Check alignment of quarterwave waveplates. If this does not solve the problem, the waveplates are defective or the Nd:YAG rod is excessively birefringent.

SYMPTOM #3: Excessive Timing Jitter in Seeded and Unseeded Output Pulses.

POSSIBLE CAUSE:
Host laser has insufficient holdoff.
REMEDY:
Check holdoff condition of the host laser with the rejected beam blocked any of the alignment mirrors (before mirror #3 per"typical" arrangement, shown in Figure 2-6). This checks the holdoff of the host laser totally decoupled from the seeder. Holdoff should be strong with a large margin for increasing the flashlamp energy before breakthrough occurs (if ever).
Next, unblock the rejected beam and recheck the holdoff condition. If holdoff is notably worse than with the rejected beam blocked, reflections off of the alignment mirrors or seeder telescope may be responsible.

POSSIBLE CAUSE:
Poor frequency overlap.
REMEDY:
Recheck the frequency overlap, per Section 2.2.4, to verify that the seed laser frequency laser is not adjusted to run near a mode hop.

POSSIBLE CAUSE:
Host laser has excessive vibration or misalignment.
REMEDY:
Check the host laser for sources of vibration or misalignment, such as cooling hoses touching the mirror mounts or the seeder support platform.

POSSIBLE CAUSE:
Lamp energy is too high.
REMEDY:
Turn down lamp joules and see if jitter improves. If energy is still at an acceptable level, then this is the solution.

POSSIBLE CAUSE:
Photodiode receiving insufficient signal.
REMEDY:
See photodiode procedure in Symptom #1.

SYMPTOM #4: Rapid Scanning of Piezoelectric Voltage Range.

POSSIBLE CAUSE:
Water temperature unregulated.
REMEDY:
Check mechanical clamping of resonator rods to angle brackets for tightness. Check for binding of high reflecting end mirror mount bracket on aluminum "L". If quartz resonator rods are used, check for cracks.

SYMPTOM #5: Injection Seeder Does Not Acquire Lock Quickly.

POSSIBLE CAUSE:
Photodiode receiving insufficient signal.
REMEDY:
Check pin 6 of the Diagnositc Connector, as described for Symptom #1. The photodiode must receive sufficient signal to be driven well into saturation.

POSSIBLE CAUSE:
Dither magnitude insufficient.
REMEDY:
Check to see that the piezoelectric tuning element is not excessively loaded due to over tightening of high reflecting end mirror delrin endcap. Increase dither magnitude via adjustment of the Dither Potentiometer, located on top of the laser head.

POSSIBLE CAUSE:
External cooling water has frequent and large pressure fluctuations.
REMEDY:
Check external cooling water for pressure fluctuations. Install pressure regulator set at 20 psi if necessary.

SYMPTOM #6: Q-switch BUT Reduction Changes (slowly) by more than 10% after external cooling water is flowing.

POSSIBLE CAUSE:
Etalon effects from various coated and uncoated surfaces within the resonator.
REMEDY:
With the Mode Switch in MANUAL, change the Laser Frequency Potentiometer (located on top of the laser head) while observing the reduction in Q-switch BUT. As the seed laser is tuned in and out of resonance with the host, if the Q-switch BUT periodically changes from a large BUT to a smaller BUT, some element within the host cavity is acting as an etalon. This should be tracked down and corrected by tilting the element off axis. This would happen every 5 to 25 resonances of the seeder with the host, and is not to be confused with the mode hopping of the seed laser which happens after more than 100 resonances or >$1cm^{-1}$ of seed laser tuning.

SYMPTOM #7: No output from the seed laser.

POSSIBLE CAUSE:
Laser diode has reached the end of its life or the seeder NPRO has misaligned.
REMEDY:
The unit must be returned to Lightwave for repair.

APPENDICES

APPENDIX I: PRODUCT SPECIFICATIONS

HOST SPECIFICATIONS

Performance Parameter	Specification
1) Spatial Mode	1) TEMoo or DCR "dot" (see Note 2)
2) Beam Diameter	2) Unaffected by seeding
3) Beam Divergence	3) Unaffected by seeding
4) Beam Pointing Stability	4) Unaffected by seeding
5) Output Pulse Time Jitter	5) 1 nsec rms from sync pulse is typical
6) Pulse to Pulse Energy Stability	6) ±1% @ 1064 nm is typical
7) Average Power Stability	7) 5% per 10 hours @ 1064 nm is typical
8) Pulse width (1064nm)	8) Unaffected by seeding
9) Temporal Pulse Profile	9) Smooth. Transform limited to within 5%
10) Percentage of Smooth Pulses	10) >99%
11) Power Loss @ 1064nm Seeded	11) <5%
12) Frequency Modulation	12) <±10 MHz
13) Warmup Time	13) 20 minutes
14) Operating Temperature Range	14) Normal lab environment

INJECTION SEEDING SYSTEM SPECIFICATIONS

Performance Parameter	Specification
1) Gain Media	1) Nd:YAG
2) Wavelength	2) 1064 nm
3) Output Power (mW)	3) 2.0 mW
4) Polarization Ratio	4) 100:1
5) Spatial Mode	5) TEMoo
6) Linewidth	6) -5 kHz/msec
7) Frequency Jitter	7) -75 kHz/sec
8) Frequency Drift	8) -200 MHz/°C in ambient
9) Frequency Scanning Range	8) 15 GHz

Notes

1. Specifications are subject to change without notice.
2. Performance required of the host laser:
   a. A high degree of mechanical stability
   b. Single transverse mode
   c. Entry point for the seed light (rear mirror, polarizer)
   d. <10mJ per pulse returned along the seed entry path
3. The minimum repetition rate for seeding is 4 Hz.
4. Lightwave Electronics seed laser systems are manufactured under one or more of the following patents: 4578793, 4455657, 4734912, 4749642, and/or 4797896.

APPENDIX II: FOOTNOTES

1. W. Koechner, Solid-State Laser Engineering (Springer-Verlag, New York,1976).
2. A.E. Siegman & R. Arathoon, "Modes in Unstable Optical Resonators and Lens Waveguides", IEEE J. Quantum Electronics, 3, 156 (1967).
3. L.A. Rahn, "Feedback Stabilization of an Injection Seeded Nd:YAG Laser", Appl. Opt. 24, 940 (1985)
4. Y.K. Park, G. Guiliani, and R.L. Byer, "Unstable Single-Axial-Mode operation of an Unstable Resonator Nd:YAG Oscillator by Injection Locking", Opt. Lett. 5, 96, 1980.
5. E.S. Fry and S.W. Henderson, "Suppression of Spatial Hole Burning in Polarization Coupled Resonators", Appl. Opt. 25, 3017 (1986).
6. T.J. Kane and R.L. Byer, "Monolithic, Unidirectional Single Mode Nd:YAG Ring Laser",Opt. Lett. 10, 65 (1985).

Additional Reading

1. R.L. Schmitt and L.A. Rahn, "Diode-laser -pumped Nd:YAG laser injection seeding system", Appl. Opt. 25, 629 (1986).
2. Johnson, Herbst, Scerbak and Kane, "Injection Seeded High Power Laser System", Lasers 87 Conference.

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Chapter VIII Operator Notes

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