OPERATIONS MANUAL

Jupiter II Reactive Ion Etcher

with 2-4 Gas PCM

TABLE OF CONTENTS

INTRODUCTION

This manual is broken down into sections dealing with all issues related to the Jupiter II Reactive Ion Etcher.

This includes detailed installation instructions, specifications, and a full description of the equipment and all controls and indicators on the equipment components.

A safety hazards and precautions section points out any risks involved with equipment operation along with recommendations for safely operating and maintaining the system. The safety features included with the system are also outlined.

A section on theory of operation explains the principals behind plasma generation and the variables that are under operator control during process development and optimization. The goal is to give the beginning plasma process engineer a starting point for developing plasma treatments for various applications using the Jupiter II equipment. The user should contact March Instruments if more detailed process development assistance is required for a specific application.

Another section gives the step by step details for system operation.

The service information section contains the information on warranties, trouble shooting, equipment repair, and parts replacement.

The appendix lists a detailed explanation of the effect of changing the variables in the plasma process and a characterization of some aspects of the system.

A glossary defines the terms used in the manual.

Textural conventions used in the manual are as follows:
In the Installation Instructions section, parts that the installer needs to attach to the main unit are listed in all capital letters. In operating procedures, call-outs for buttons the operator is instructed to actuate are listed in all capital letters. References to other sections of the manual are given with section heading title and page number. Section headings are in bold print and underlined.

Nomenclature for data entry in this manual uses millitorr (mTorr or mT) in reference to pressure, watts (w) for power, and seconds (secs) or minutes (mins) for time.

This manual can be ordered under March Instruments part number 021-1003.

EQUIPMENT OPTIONS

This is a list of all non-standard system accessories. Equipment can be upgraded to include these options. For additional information, contact March Instruments.

PUMP OIL MIST ELIMINATOR

Collects and condenses the oil mist generated during pump operation. This leads to lower pump oil consumption and a cleaner operation.

If the system is to be run with a fluorine based process gas, a special mist eliminator is required.

PUMP OIL FILTRATION UNIT

Pump oil gets dirty during the course of normal operation. Certain plasma processes will cause the oil to accumulate contaminants at an accelerated rate. The pump oil filtration unit is a device that attaches to the vacuum pump and keeps the pump oil clean. This cuts down on pump maintenance and increases the life of the pump.

ADDITIONAL MASS FLOW CONTROLLERS

The standard system is equipped with two Mass Flow Controllers (MFCs). If the operator requires more than two process gases, two additional MFCs can be installed as an option.

BOTTOM ELECTRODE OPTIONS

The bottom electrode (where the sample is placed) can be supplied in three different configurations depending on the plasma application and composition/geometry of the sample to be processed. The chamber gas flow pattern is different for each configuration.

The standard electrode is solid. The other two available options are perforated and slotted.

SAFETY

This section covers the safety issues associated with the Jupiter II. It describes the system safety features. Any inherent equipment hazards are outlined. Details on necessary precautions for safe operation are provided.

Alert boxes containing the words ”NOTE”, “CAUTION”, and “WARNING” are used in various advisories in this manual. “CAUTION” implies that the action could possibly cause damage to equipment or injury to personnel if the proper procedures are not followed. Use of the word “WARNING” implies that the action places the operator in a situation that has a possibility of serious injury or death if the proper procedures are not followed. “NOTE” alert boxes are advisories that point out important information that is not obvious to the reader but will not lead to any hazardous situations or immediate equipment damage if not followed.

SAFETY FEATURES

The following is a description of the safety features designed into the system. Schematics are in the back of the manual.

SAFETY INTERLOCKS

An interlock prevents the RF power from being activated if the chamber pressure is out of the specified range (above 2000 mTorr). This interlock functions via a pressure gauge sensor that prevents RF power from being turned on until the threshold pressure of 2000 mT is reached. This feature serves as a safety interlock since it precludes the possibility of activating the RF power when the chamber door is open. It also helps to prevent damage to the equipment since running at high pressures is hard on both the generator and tuning network.

An additional push button RF interlock is mounted on the chamber lid hinge. This prevents activation of the RF power unless the lid is closed.

A gas flow interlock prevents gas flow into the chamber until a threshold pressure of 150 mT is achieved. This prevents potentially flammable or toxic gases from flowing while the system is at atmospheric pressure.

WARNINGS AND PRECAUTIONS

When used properly, your Jupiter II system is very safe. The purpose of this advisory is simply to point out possible hazards resulting from misuse of the equipment and to suggest ways of operating the equipment as safely as possible.

ELECTRICAL

As with all electrical equipment, caution is warranted whenever any external panels are removed and/or electrical wiring is exposed. Only qualified technicians should perform maintenance, repair or installation on the equipment. Per OSHA 29 CFR 1910.147 (Control of Hazardous Energies, Lockout/Tagout), if possible the equipment should be disconnected from the power source and a lockout device attached to the electrical disconnect before beginning any work. The lockout device prevents reenergization of the equipment while the maintenance/repair is occurring.

RADIO FREQUENCY (RF) EXPOSURE

A potential hazard from RF exposure exists if the system is operated without the external cover in place. This is not recommended. This system runs at an RF frequency of 13.56 Mhz and the standard RF generator runs at a maximum power of 600 watts.

CHAMBER TEMPERATURE

The plasma chamber can become quite hot during some processes. Exercise caution to prevent burns.

CHEMICAL HAZARDS

The fluorinated pump oil (Krytox) is a skin and eye irritant. Gloves and eye protection should be used when changing or adding pump oil.

The Material Safety Data Sheet for Krytox is included for reference at the back of the manual.

PROCESS GASES

Certain process gases selected for use with this equipment may be hazardous. Some may require special precautions. These precautions vary depending on the gas. Consult with your safety officer to ensure proper precautionary steps are taken before bringing any new gas into your facility. Take care to insure that gas lines containing toxic or flammable gases do not leak.

Gas line integrity can be confirmed simply by opening the valve on the gas cylinder then quickly closing it again. If the pressure reading on the regulator drops within one minute, there is a substantial leak that could be dangerous.

UNPACKING

CAUTION: COMPONENTS OF THE JUPITER II RIE SYSTEM ARE HEAVY. USE PROPER LIFTING PROCEDURES TO AVOID INJURY TO PERSONNEL.

The Jupiter II Plasma System is completely tested and inspected at the factory before shipping. Inspect all shipping cartons before unpacking. If there is any reason to suspect damage to the cartons or their contents, make note of the damage and report it to the shipping company immediately.

Using the included packing list, check to ensure that all listed components have arrived at your facility. Unpack the shipping cartons carefully and inspect the main plasma unit and all other system components for any damaged or missing items.

If any component is damaged or missing, notify the shipper and notify the March Instruments Customer Service Department by telephone(925 827 1240) or FAX (925 827 1189) immediately. Claims based on late notification of shipping damage will be denied.

Keep all shipping containers and materials in case it should be necessary to return any item to March.

Place the system components on the selected work surfaces. Remove all packing materials including any that might be present in the chamber of the system.

LONG TERM STORAGE

If the plasma system and vacuum pump are to be placed in long term storage, take the following precautions in order to keep the equipment in good working condition.

All system components should be placed in protective packaging. A desiccant should be placed in the packaging to minimize moisture exposure. Storage should be in a room with humidity less than eighty percent.

Before packaging and storing the vacuum pump, fill the pump reservoir with oil to the proper level and run the pump for five minutes to lubricate the seals. During the time the pump is stored, you will also need to run the pump for five minutes every three months in order to keep the seals lubricated.

INSTALLATION

The following section outlines the requirements for system installation, recommended working area allowance, step by step instructions for assembly, and initial startup procedure. The installer should refer to Safety Warnings and Precautions and Unpacking sections on pages 7 and 8 before beginning installation.

FACILITIES REQUIREMENTS:

The specifications and requirements for the system and applicable options are listed in the following table. All power cords are supplied by March Instruments.

PROCESS CONTROLLER:

Power Supply:.....................	Single Phase 110VAC or 220VAC +/-10% (Specified at time of order). 50-60 Hz @ 15 Amps. 18 AWG, 3 wire.
Process Gases:.....................	Regulated to 10-15 PSIG. Connections made by either .25” O.D. Stainless Steel or Teflon tubing (Supplied by purchaser).
Purge Gas:...........................	Nitrogen or Compressed Dry Air regulated to 45 PSIG (Gas, regulators and .25” tubing supplied by purchaser).
External Gas Fittings:...........	Swagelok compression fittings, .25” O.D.
Chamber Cooling:................	Distilled water only.

RF GENERATOR:

RFX-600:

Power Supply:.....................	Single Phase 110VAC or 220VAC +/-10%. 50-60 Hz @ 15 Amps. 14 AWG, 3 wire.
Power Output:.....................	600 Watts +/-2% @ full load output into 50 Ohm impedance.
Dimensions:........................	8.5”W x 7”H x 18”L.

SEREN R600:

Power Supply:.....................	Single Phase 100-125VAC, 12 amps or 198-250VAC, 5 amps. 50-60 Hz, 14 AWG, 3 wire.
Power Output:.....................	650 Watts @ full load output into 50 Ohm impedance.
Dimensions:........................	8”W x 8.75”H x 19”D.

SEREN R300:

Power Supply:.....................	Single Phase 100-125VAC. 50-60 Hz, 14 AWG, 3 wire.
Power Output:.....................	300 Watts full load output into 50 Ohm impedance.
Dimensions:........................	8”W x 5.25”H x 16”D.

MPS 300:

Power Supply:.....................	Single Phase 110VAC or 220VAC +/-10%. 50-60 Hz @ 15 Amps. 14 AWG, 3 wire.
Power Output:.....................	300 Watts +/-5% @ full load output into 50 Ohm impedance.
Dimensions:........................	8.5”W x 7”H x 18”L.

VACUUM PUMP

Capacity:.............................	2015CP 11 CFM or 2033CP 27 CFM (11 CFM minimum recommended).
Power Supply:.....................	2015CP - Single Phase 110VAC or 220VAC +/-10% @ 50-60 Hz and 15 Amps. 14 AWG, 3 wire. 2033CP - Single Phase 110VAC or 220VAC +/-10% @ 50-60 Hz and 15 Amps. 14 AWG, 3 wire.
Lubricant:...........................	Charged with either Perfluorinated Krytox or Fomblin oil.
Exhaust:............................	2015CP - NW-25 connection (1” exhaust tubing supplied by purchaser) 2033CP - NW-40 connection (1.5” exhaust tubing supplied by purchaser).
Dimensions:.......................	2015CP - 22”L x 11”H x 5.5”W 2033CP - 30” L x 14”H x 8”W.

<u>Optional Equipment</u>

PUMP OIL FILTRATION UNIT:

Power Supply:.....................	Single Phase 110VAC or 220VAC +/-10%. 50-60 Hz @ 8 Amps. 14 AWG, 3 wire.
Dimensions:........................	13”W x 14.5”H x 17.5”L.

CHILLER:

Power Supply:.....................	Single Phase 110VAC* +/-10%. 50-60 Hz @15 Amps. 14 AWG, 3 wire.
Output:...............................	2 GPM @ 6 PSI. *Distilled water only.*
Connections:.......................	Swagelok fittings, .25” O.D. (Either .25” Stainless Steel or Teflon tubing supplied by purchaser).
Dimensions:........................	25.5”W x 12”H x 25”L.
Temperature:......................	50-60 Degrees F.

CONTACT ANGLE MEASURING SYSTEM:

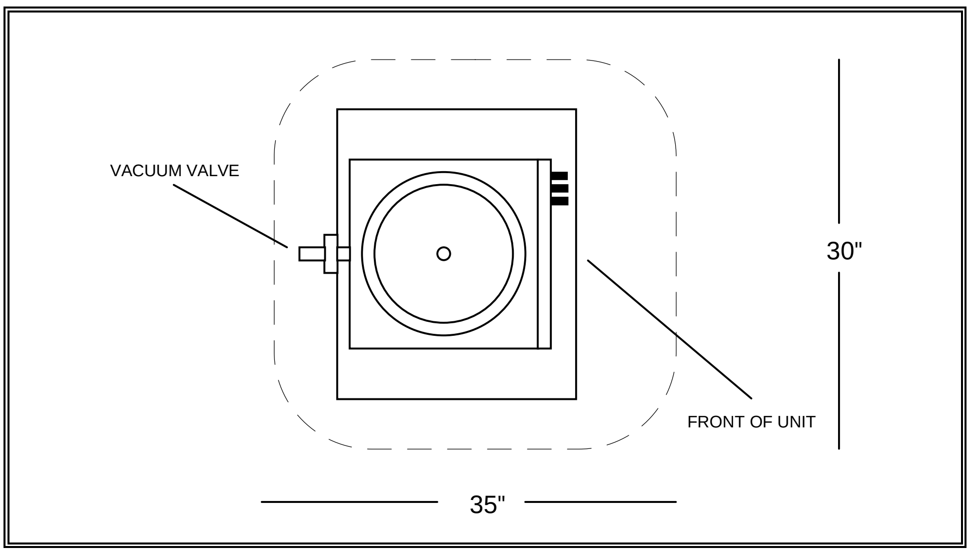
Power Supply:..................... Single Phase 110VAC or 220VAC +/-10%. 50-60 Hz @ 2 Amps. 3 wire, 14 AWG.*

Dimensions:....................... 11"W x 16"H x 22.5"L.

NOTE: ALL CONNECTIONS FOR PROCESS GAS BETWEEN GAS BOTTLES AND JUPITER II MUST BE MADE USING CORROSION RESISTANT MATERIALS SUCH AS TEFLON OR STAINLESS STEEL. OTHER MATERIALS CAN CORRODE GENERATING PARTICULATE MATTER WHICH WILL CLOG GAS SHUTOFF VALVES AND MASS FLOW CONTROLLERS.

RECOMMENDED WORKING AREA ALLOWANCE

The following diagram outlines the minimum recommended working space recommended for the Jupiter II system.



SYSTEM ASSEMBLY

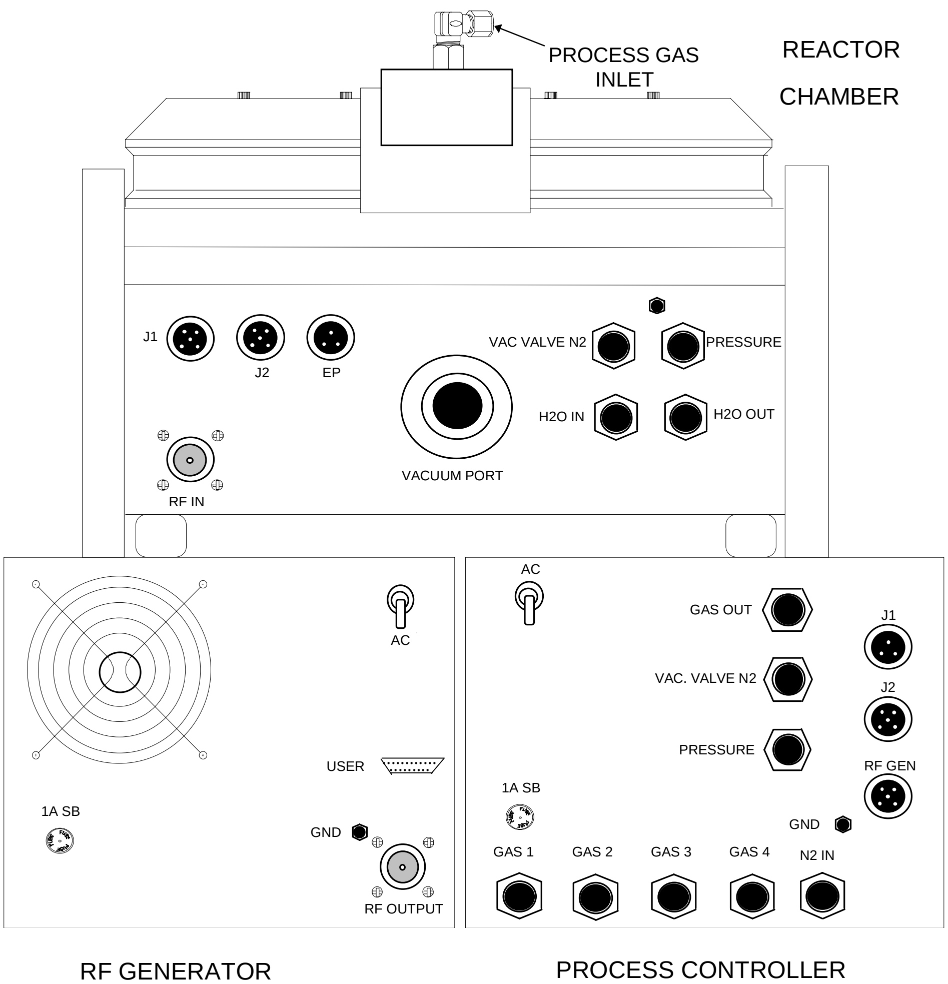
To facilitize the system, please complete the following steps in the order listed:

CAUTION: HAZARDOUS VOLTAGES AND CURRENTS ARE FOUND WITHIN THE ENCLOSURE OF THIS EQUIPMENT. EXERCISE ALL POSSIBLE PRECAUTIONS TO AVOID INJURY TO PERSONNEL OR EQUIPMENT. ONLY QUALIFIED TECHNICIANS SHOULD PERFORM THE INSTALLATION OF THIS EQUIPMENT.

1. Place the RF Generator and Process Controller on the selected work surface. Place the Reactor Chamber atop these two modules.

2. Connect the vacuum pump to the VACUUM PORT fitting located on the back of the Reactor Chamber with the provided flexible tubing.

3. Connect the dry air or nitrogen source to the compression fitting labeled "N2 IN" on the back of the Process Controller.



REAR VIEW OF JUPITER II SYSTEM **FIGURE 1.**

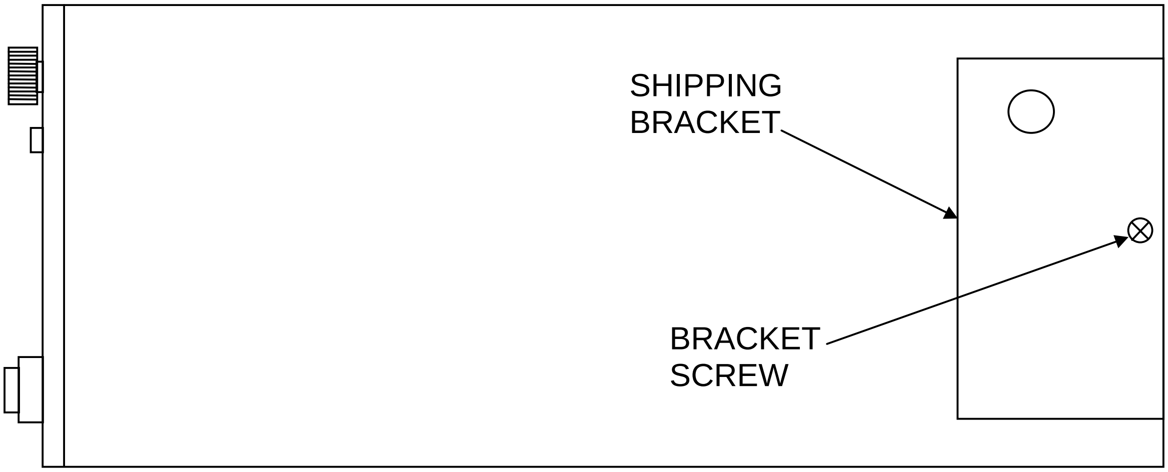
4. Connect the desired process gases to the Process Controller compression fittings labeled "GAS1”, "GAS 2", etc. using stainless steel or Teflon tubing. Ensure that the gases are properly regulated (10-20 psi).

5. Connect the Process Controller compression fitting labeled "VAC. VALVE N2" to the Reactor Chamber compression fitting labeled "VAC. VALVE N2" using the provided 1/4" tubing and fittings. This connection will provide the nitrogen gas pressure necessary to open and close the vacuum valve.

6. Connect the Process Controller compression fitting labeled "PRESSURE" to the Reactor Chamber compression fitting labeled "PRESSURE" using provided 1/4" tubing.

7. Connect the Process Controller compression fitting labeled "GAS OUT" to the PROCESS GAS INLET atop the Reactor Chamber using provided 1/4" tubing.

8. Remove the generator from it’s box. If using a Seren brand generator, remove the shipping brackets from the sides of the generator by removing each bracket screw as shown in the diagram below. Save the generator box and brackets in case the generator needs to be shipped back to March.



SIDE VIEW OF SEREN GENERATOR **FIGURE 2.**

9. Connect the RG8 cable between the ‘N’ connector labeled "OUTPUT" or “RF OUT” on the RF Power Generator and the ‘N’ connector labeled "RF IN" on the system rear panel.

10. Connect the generator control cable between the D type connector labeled "RF GEN" on the system rear panel and the D type connector labeled "USER" or “ANALOG INTERFACE” on the RF Power Generator.

11. Attach the Process Controller connector labeled "J1" to the Reactor Chamber connector labeled "J1" using the provided cable.

12. Attach the Process Controller connector labeled "J2" to the Reactor Chamber connector labeled "J2" using the provided cable.

13. Ground the Process Controller by attaching one of the provided grounding straps between the post marked “GND” on the Process Controller and the post on the Reactor Chamber module.

14. Ground the RF Generator by attaching the provided grounding strap between the post on the Reactor Chamber module and one of the screws holding the RF Generator cover in place.

15. Connect water cooling return line between water cooler inlet and port labeled "H2O OUT" on Reactor Chamber.

16. Connect water cooling input line between water cooler outlet and port labeled "H2O IN" on Reactor Chamber.

NOTE: USE DISTILLED WATER ONLY. TAP OR DEIONIZED WATER MAY CAUSE CORROSION OR BUILD-UP IN THE CIRCULATION LINES.

17. Connect RF Power Generator power cord to a voltage source.

18. Connect the Process Controller power cord to a voltage source.

19. After ensuring the exhaust line is connected properly, connect the vacuum pump power cord to a voltage source. Pump exhaust should have an exhaust line that vents outside of the facility. Some of the more hazardous gases may require the use of an exhaust scrubber.

INITIAL STARTUP

After the machine has been properly installed, you can begin operation by following the steps detailed below:

1. Be sure that the system is correctly installed as specified in this manual and that all fittings are leak tight.
2. Turn on the AC switch on the back panel of the Process Controller. Check that the front panel switches and displays light up.
3. Close the reactor chamber lid.
4. After ensuring that RF Generator front panel RF switches are set to OFF position, turn on AC switch or circuit breaker on the back side of the RF Generator
5. Turn on RF Power Generator by pressing the POWER (RFX-600 generator) or ON/OFF (R300 generator) button, or pressing the rocker switch (R600 generator).
6. *If using an RFX-600*, disable Remote Control and Remote Signal functions by toggling those buttons on the generator so that the LEDs are not lit. The generator is now set up for RF power control through it's front panel.
   If using an R300, place the LOCAL/REM switch on the generator to the LOCAL position. The generator is now set up for RF power control through it's front panel.
   If using an R600, press the PROG button on the generator to enable programming options. Press the Arrow buttons until ANALOG is shown on the generator display. Turn the generator front panel dial so that ANALOG is "Disabled". Press the PROG button followed by the RUN button to back out of the programming mode. The generator is now set up for RF power control through it's front panel.
7. Toggle the RF tuning switch on the main system to the Auto position.
8. Leak check gas lines by opening the valve on the gas cylinder then quickly closing it again. If the pressure reading on the regulator drops within one minute, there is a substantial leak in the line.

<u>CAUTION:</u> CERTAIN PROCESS GASES SELECTED FOR USE WITH THIS EQUIPMENT MAY BE HAZARDOUS. CONSULT WITH YOUR FACILITIES SAFETY OFFICER TO ENSURE PROPER PRECAUTIONARY STEPS ARE TAKEN BEFORE THESE GASES ARE CONNECTED OR USED.

9. Turn on process and purge gases at their sources and adjust the regulators to the specified gas pressure (see <u>Facilities Requirements</u>).
10. Perform the vacuum check described on the next page.

Vacuum Check

When first starting a vacuum system it is advisable to check the vacuum integrity of all components and connections. To do so:

1. Depress the MODE SELECT switch on the Process Control Panel to select manual mode.
2. Make sure the gas FLOW CONTROL buttons are turned off.
3. Depress the START button on the Process Control Panel to commence pumping down the chamber. Start timer.
4. Record the time required to reach a pressure of 100 mTorr (.10 on the display). The pressure should fall below 100 mTorr less than 5 minutes after pressing the START button.
5. Wait 20 minutes to allow any residual moisture to exit the system and record the ultimate pressure shown on the display.
6. Turn off the nitrogen or compressed air source and disconnect the compressed gas line from the system. The vacuum valve is now closed and the chamber is isolated from the pump. If the system is not vacuum-tight, the pressure will slowly rise in proportion to the size of the leak.
7. Record the leak rate in mTorr/minute. The system pressure should not rise more than 50 mTorr/minute (.05 on display).
8. After testing, reconnect the gas line and turn on the compressed gas source.
9. Save the vacuum check data for future reference and comparison purposes. This same procedure should be run periodically in order to recheck the vacuum integrity. The form on the following page is included for this purpose.

VACUUM INTEGRITY CHECKLIST

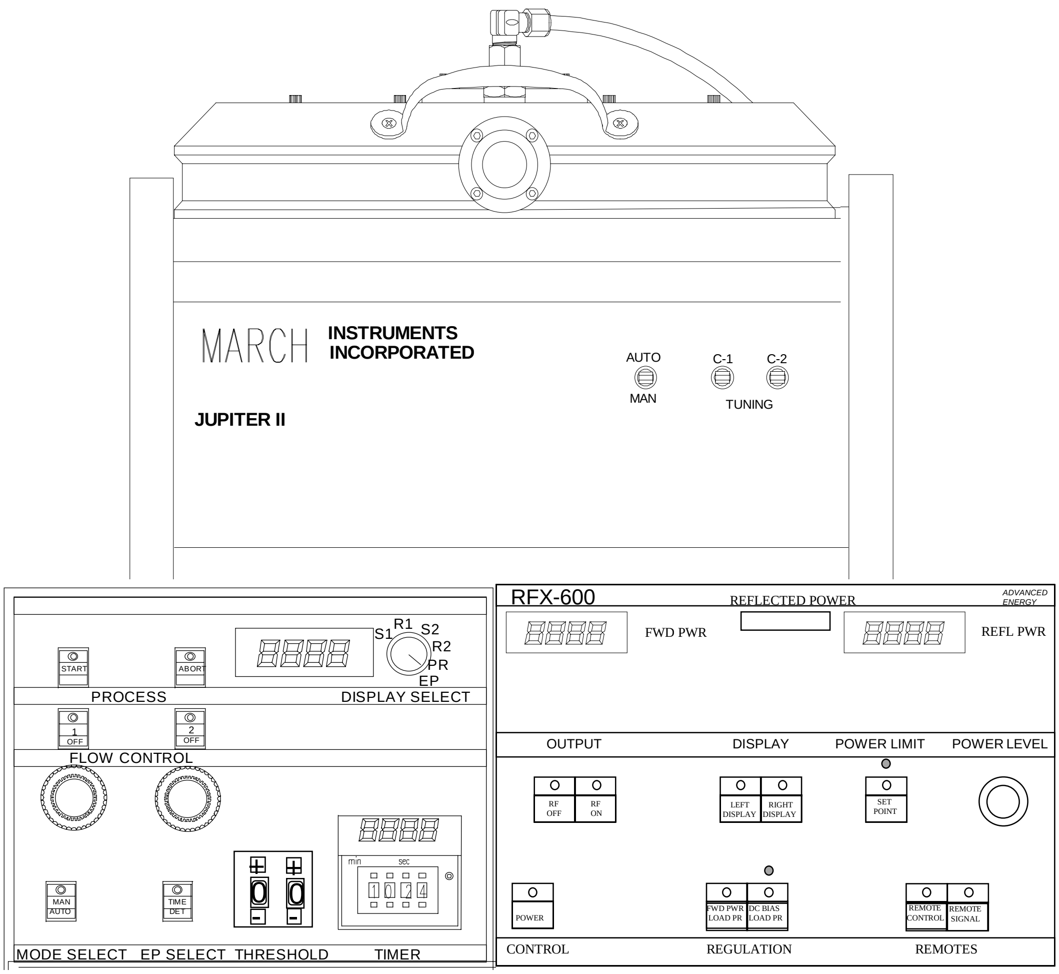
DATE:	PRESSURE AFTER 15 SECONDS (mTorr):	TIME TO 100 MTORR:	PRESSURE AFTER 20 MINUTES (mTorr):	CHAMBER LEAK RATE (mTorr/Min):

EQUIPMENT ORIENTATION

This section includes a general description of the overall plasma system as well as a more detailed description of the controls and indicators on the RF Generator, Process Controller, and Chamber modules.

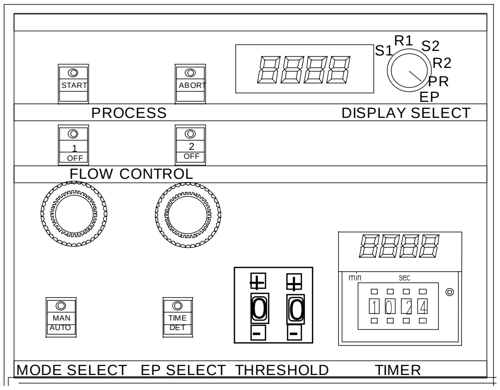
GENERAL EQUIPMENT DESCRIPTION

The Jupiter II Reactive Ion Etcher consists of three modules: a Reaction Chamber, a Process Controller, and a solid state RF Power Generator:



Designed for maximum performance and flexibility, March Instrument's Jupiter II Reactive Ion Etching systems are tabletop etchers used primarily in failure analysis and small scale production plasma etching applications.

PROCESS CONTROLLER



The Process Controller monitors and regulates the variable parameters of the plasma process, including chamber pressure, process duration and gas flow rates. The Process Controller houses two (or an optional four) Mass Flow Controllers for regulation of process gas flow, and the system is equipped with a Baratron pressure gauge for pressure determination.

The unit can be operated in either an automatic or manual mode. In automatic mode built-in sequencing will:

- Vacuum down the chamber to the preset base pressure level.
- Turn on the selected gas(es) to the preset flow rate.
- Turn on the RF power to the preset level when the gas flow has stabilized.
- Maintain these parameters until desired processing time has elapsed.

The Process Controller will then shut off the RF power, perform a complete evacuation of process gases, and vent the chamber to atmospheric pressure. Manual mode provides the same control over process parameters but requires that each sequence step be initiated by the operator.

Process Controller Elements

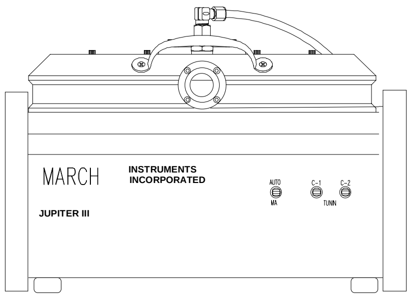
- Two Mass Flow Controllers (or an optional four)
- Baratron pressure gauge
- Automated sequencing with manual override and process timer

RADIO FREQUENCY POWER GENERATOR AND MATCHING NETWORK

The Jupiter II is equipped with a solid state RF (Radio Frequency) generator with a fixed frequency of 13.56 MHz. Impedance matching is achieved through the employment of an Inductive-Capacitive tuning network. The tuning network functions by adjusting the forward to reflected power ratio during processing in order to achieve the best power transfer to the plasma. The forward power is the total power output from the generator at a given setting. Reflected power is undesirable and should be minimized during operation. It is the portion of the forward power that is lost from the plasma and reflected back towards the generator.

When the tuning network is operated manually, reflected power must be continuously monitored in order to keep it at a minimum. In auto mode, the tuning is automated for hands-off operation and convenience.

REACTION CHAMBER MODULE



The top-loading chamber is designed to ensure anisotropic etching and maximize selectivity, uniformity, and speed. A ceramic ring focuses the plasma on the bottom electrode where the sample is placed, thus optimizing power utilization to increase anisotropy and etch rate. The bottom electrode is water cooled to maintain the sample at a low temperature during processing. The chamber is equipped with a circular quartz viewing window for observation of the plasma process. The primary chamber material is anodized aluminum; other components are manufactured from ceramic and quartz. No plastic components are used in the construction of the chamber.

JUPITER II SPECIFICATIONS

The following are the specifications for the Jupiter II system:

Exterior Dimensions

- Reactor Chamber: 13" W (33 cm) x 10" H (25 cm) x 18" D (46 cm)
- Process Controller: 8.5" W (21.6 cm) x 7" H (17.8 cm) x 20" D (50.8 cm)
- RF Generator: 8.5" W (21.6 cm) x 7.4" H (18.8 cm) x 18" D (45.7 cm)

Weight

- Reactor Chamber: 30 lbs (13.6 Kg)
- Process Controller: 17 lbs (7.7 Kg)
- RF Generator: 27 lbs (12.3 Kg)

Chamber Material

- Anodized Aluminum

Chamber Interior Dimensions

- 4" or 6 " wafer capability, .75" material height limitation.

Installation Working Surface

- Designed for use on table top or counter.

RF Power Generator

- 0-300 or 0-600 watt RF Power Generator.
- 13.56 MHz operating frequency.
- Solid state circuitry.
- Automatic or Manual impedance matching.

CONTROLS AND INDICATORS

This section describes the controls and indicators on the Jupiter II system components.

PROCESS CONTROLLER/CHAMBER

The following is a description of the controls and indicators on the Jupiter II Process Controller and Chamber modules. Each control and indicator is numbered on Figure 3 (page 22).

Powering Up and Powering Down System

The **AC** toggle switch (Main Power) is located at the rear of the Process Control module.

1. **START**. Initiates the complete process cycle when in the Automatic operating mode. When in Manual operating mode, evacuates the chamber and activates any gas flow channels that are enabled (see 3).

Operational Mode Selection

2. **MODE SELECT**. Toggles the machine between automatic and manual operating modes.

Automatic mode processing is selected by depressing the MODE SELECT switch to the AUTO position (LED illuminated). In this mode, the process controller will initiate and control all process steps. The operator simply presses the START button.

Manual mode processing is selected by depressing the MODE SELECT switch to the MAN position (LED extinguished). In this mode, the operator must initiate all process steps individually (chamber evacuation, gas flow activation, etc.).

Process Parameter Selection

3. **Gas Activation Switches**. These are latching action switches which illuminate to indicate that gas flow through the specific channel has been enabled. Allows choice of process gases used by selecting gas flow through gas channel 1, gas channel 2, or both. Up to four channels can be used if additional mass flow controllers are purchased.

In automatic mode processing, the desired gas switches must be turned on before processing is commenced. With the channels enabled in this way, the Process Controller will automatically open the gas flow solenoid at the appropriate point in the process sequence to allow gas to flow through the mass flow controllers into the Reactor Chamber.

In manual mode processing, gas flow can be initiated by the operator when the chamber pressure reaches 150 mTorr. Also, any gas flow channels that were enabled prior to evacuating the chamber will begin flowing gas once the 150 mTorr threshold pressure is reached.

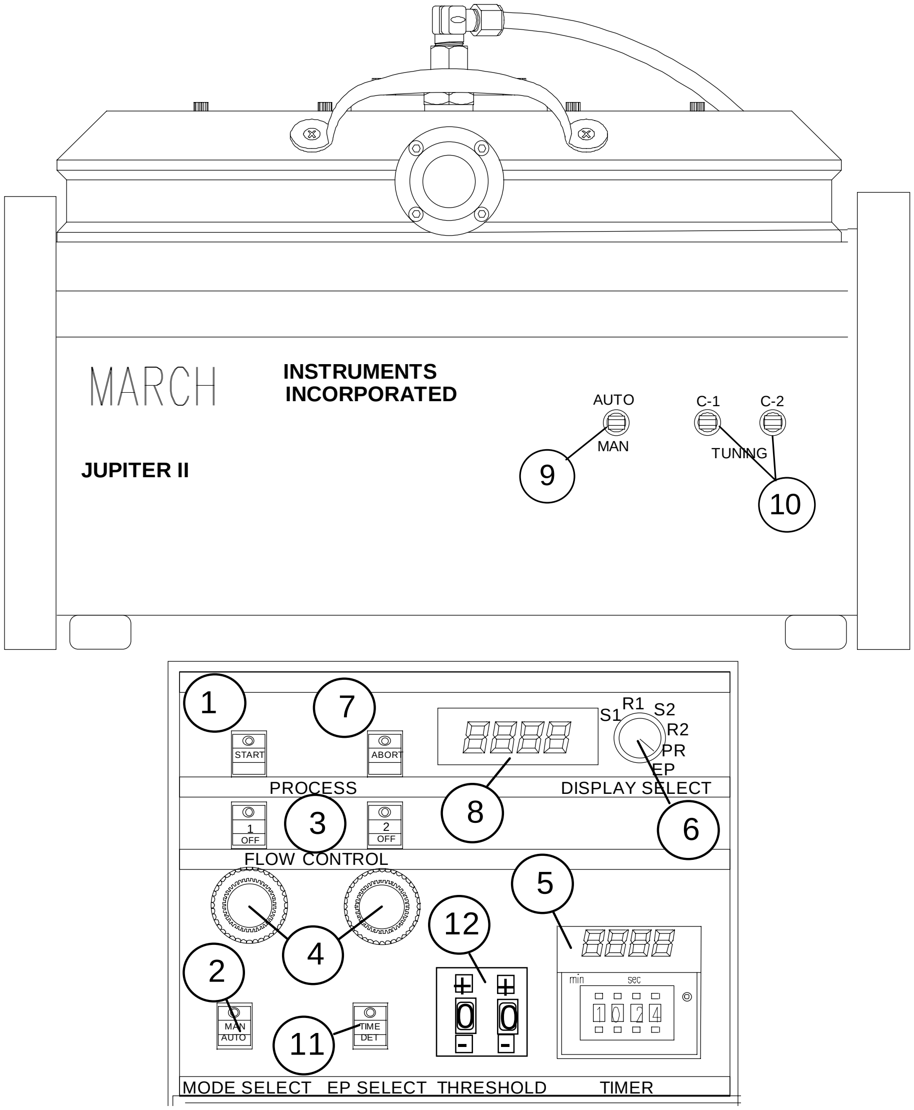


FIGURE 3.- Process Controls and Indicators

4. **Gas Flow Rate Adjustment**. Knobs for adjusting the gas flow through each mass flow controller. If the gas channel is enabled (see 3), turning the corresponding knob clockwise will increase the gas flow rate. This is seen as an increase in the reading on the chamber pressure display.

5. **TIMER**. Programmable timer used to set and monitor process duration. Controls process duration in automatic processing mode only.

Processes of up to 99 minutes and 99 seconds can be programmed by depressing the four upper (-) or lower (+) plunger switches on the TIMER. When RF power is turned on by the Process Controller, the TIMER's LED display will illuminate and indicate elapsed process time. When the programmed process time has elapsed, the Process

Controller will turn off the RF Generator and an LED on the timer face will illuminate to indicate that process ran for the full amount of programmed time.

Monitoring the Process

6. **DISPLAY SELECT**. Rotary switch which allows the front display to show either gas channel set points (S1, S2, etc.), actual gas flow readings (R1, R2, etc.), chamber pressure (PR), or Endpoint setting (EP).

Gas set points and readings are displayed as a signal voltage that ranges from 0 to 5 volts. Pressure readings are in Torr. Maximum and minimum values displayed for Endpoint are arbitrary units and vary depending on choice of process gas and operating pressure (UV light intensity dependent).

7a. **ABORT**. Momentary switch. Stops processing and vents chamber when in automatic mode of operation. In manual operation mode, this switch has no effect.

7b. **ABORT LED**. The LED on the ABORT button indicates a process fault, regardless of operational mode. Process faults include failure to pump down to the 150 mTorr base pressure within the factory set time allowance and failure to achieve the gas flow set point. Once the LED is lit, the operator must turn the AC power switch on the back of the Process Controller off and on again in order to reset the system.

8. **Display**. Four digit LED display. Will indicate either gas channel set points, actual gas flow readings, chamber pressure, or Endpoint setting depending on the position of the DISPLAY SELECT switch.

Gas set points and readings are displayed as a signal voltage that ranges from 0 to 5 volts.

Pressure readings are in Torr (A display of 0.160 would indicate that chamber pressure is 160 mTorr). The maximum pressure reading is 1.200 Torr. Any chamber pressure higher than that is displayed as 1.200 Torr.

Maximum and minimum values displayed for Endpoint are arbitrary units and vary depending on choice of process gas and operating pressure (UV light intensity dependent).

Impedance Matching Mode Selection and Accomplishment

9. **AUTO-MAN**. Latching toggle switch. Selection of Manual (user controlled) or Automatic (machine controlled) RF Tuning Mode is accomplished by placing the switch in the AUTO or MAN position.

10. **C1 & C2**. Momentary toggle switches. If the Manual tuning mode has been selected, toggling of these switches controls the positioning of the air capacitors of the Impedance Matching network. In Automatic tuning mode, these switches are deactivated.

Endpoint Detection

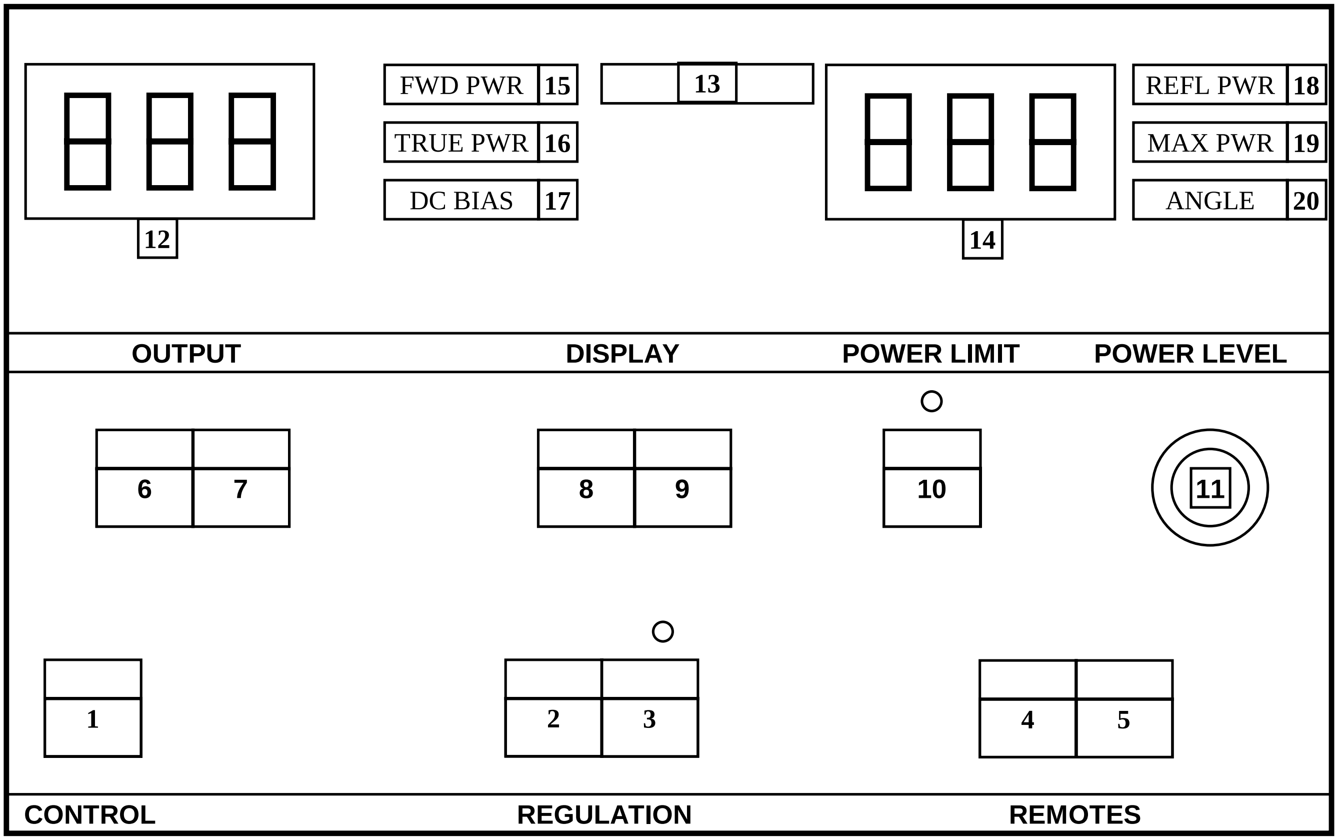
11. **EP SELECT**. Selects between Endpoint Detection and Timer modes of operation. In Endpoint Detection mode (DETECT setting), processing will stop when the UV (ultraviolet) light intensity has been reduced by a certain percentage. In Timer mode (TIME setting), processing will stop when the amount of time set into the timer has elapsed.

12. **THRESHOLD**. Adjusts the setting for Endpoint Detection. For example, if THRESHOLD is set at 50, processing will stop when the UV light intensity is 50 percent of what it was when processing began.

GENERATOR CONTROLS AND INDICATORS

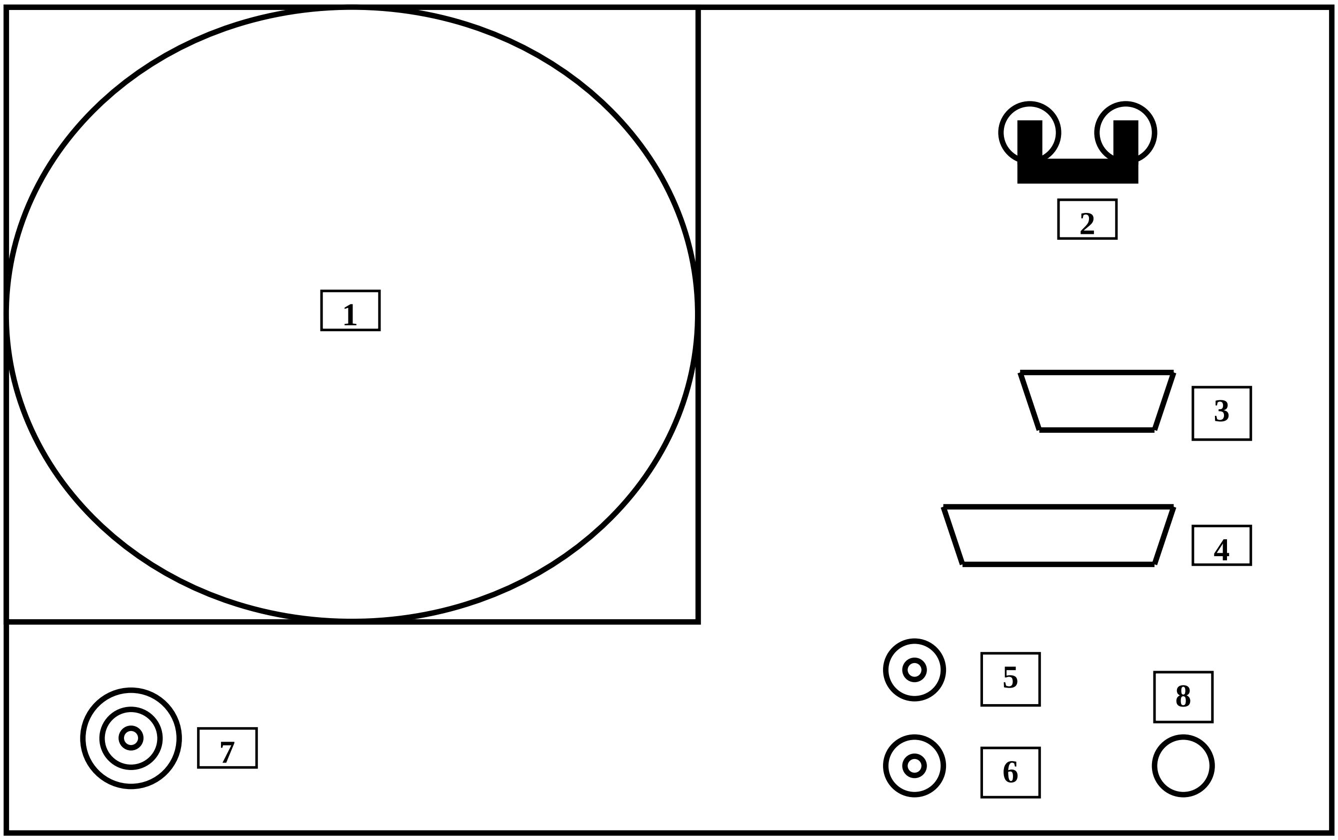
A description of the controls and indicators on the Advanced Energy RFX-600 and Seren R300 are listed on the following three pages.

<u>ADVANCED ENERGY RFX-600: FRONT PANEL</u>



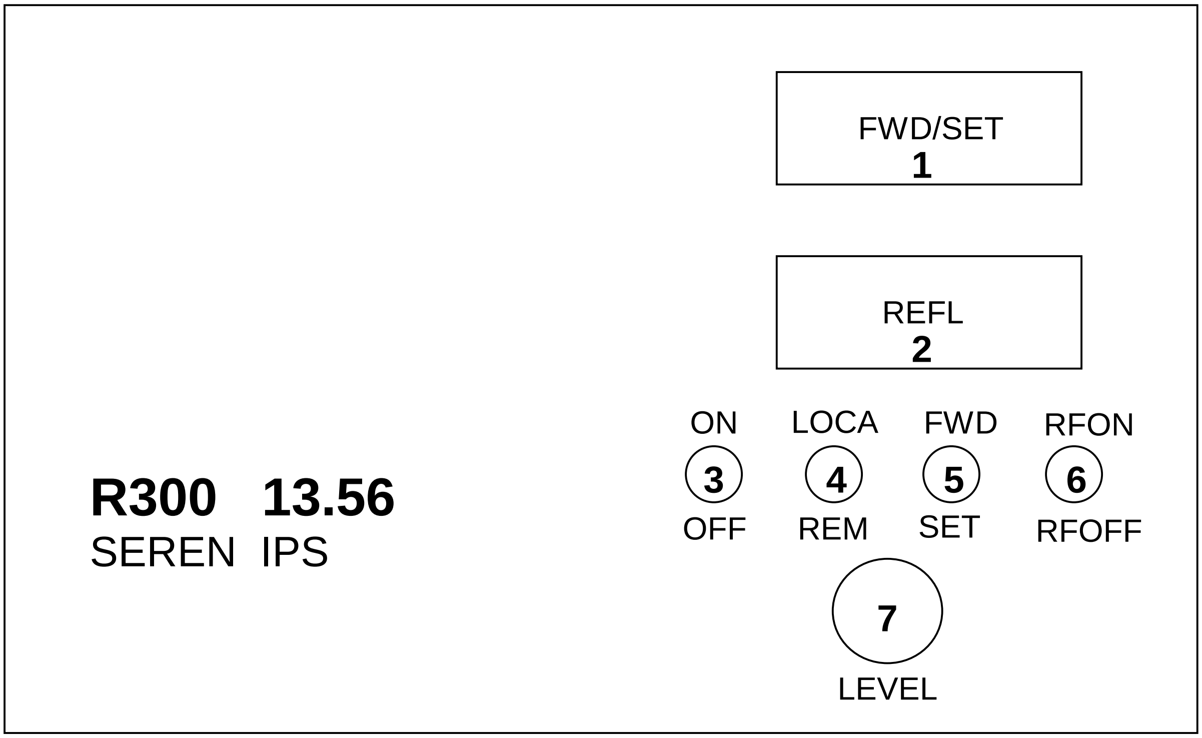
1. **POWER** - Applies power to internal circuitry. LED off = power off, LED on = power on.
2. **FWD PWR/LOAD PWR** - Provides Forward Power regulation control.
3. **DC BIAS/LOAD PWR** - Provides DC Bias regulation control. Hole above switch is to adjust scale from 0-1000 volts. Pressing both switches #2 and #3 to light LEDs will cause the load to regulate power.
4. **REMOTE CONTROL** - When depressed allows the generator RF to be turned on and off remotely through the 25 pin connector on back.
5. **REMOTE SIGNAL** - When depressed allows the power output level to be controlled remotely through the 25 pin connector. With microprocessor, PCM REMOTE SIGNAL can be used.
6. **RF OFF** - Turns off RF when generator is not in REMOTE CONTROL operation.
7. **RF ON** - Turns on RF when generator is not in REMOTE CONTROL operation.
8. **LEFT DISPLAY** - Controls what is displayed on LEFT DISPLAY. Each time switch is pushed it will cycle through **FRWD PWR**, (15); **LOAD PWR**, (16); and **DC BIAS**, (17).
9. **RIGHT DISPLAY** - Controls what is displayed on RIGHT DISPLAY. Each time switch is pushed it will cycle through **REFL PWR**, (18); **MAX PWR**, (19); and **PHASE ANGLE**, (20).
10. **SETPOINT** - When depressed will allow power output level to be set when not in REMOTE SIGNAL operation. The level will be displayed on the LEFT DISPLAY. Hole above switch will set maximum power out of the generator.
11. **POWER LEVEL** - Controls power output of the generator when not in REMOTE SIGNAL operation.
12. **LEFT DISPLAY**
13. **REFLECTED POWER BAR** - Displays reflected power with bar graph LEDs.
14. **RIGHT DISPLAY**

ADVANCED ENERGY RFX-600: BACK VIEW



1. **FAN**
2. **CIRCUIT BREAKER** - Turns fan on and allows power to front panel power switch.
3. **DIAGNOSTICS CONNECTION** - 15 pin 'D' connector used for factory servicing.
4. **USER CONNECTION** - 25 pin 'D' connector used for remote control of the generator. The blank connector that is supplied with the generator can be used to isolate RF problems between the generator and March equipment.
5. **CEX IN** - 13.56 MHz signal from master generator. Used when running dual generators.
6. **CEX OUT** - 13.56 MHz signal to slave generator. Used when running dual generators to keep them in phase.
7. **RF OUT** - 0-600 Watt @ 50 ohm impedance output to March equipment.
8. **POWER LINE CORD** - 110 VAC or 220 VAC +/-10%

SEREN R300: FRONT VIEW



1. **FWD/SET Display** - Displays forward power output or forward power set point in the range of 0-300 watts
2. **REFL** - Displays reflected power level in the range of 0-300 watts.
3. **ON/OFF** - Main power switch.
4. **LOCAL/REM** - When switch is placed in LOCAL position, RF power output level is controlled by the LEVEL knob. When in the REM position, power output is controlled remotely through the plasma system (microprocessor models only.
5. **FWD/SET Switch** - When in FWD position, forward power is shown on the FWD/SET Display. When in the SET position, forward power set point is shown on the FWD/SET Display.
6. **RFON/RFOFF** - Switch that turns the RF power on and off when in LOCAL operation.
7. **LEVEL** - Controls the RF power level when in LOCAL operation.

THEORY OF OPERATION

This chapter gives an overview of plasma and plasma processes. It outlines the basic requirements to create a plasma and what variables are under operator control.

THE PLASMA PROCESS: AN OVERVIEW

A gas plasma consists of a collection of ions, free radicals, and electrons produced when a gas is transformed to a high energy, excited state by exposure to an energy source under the right physical conditions. Natural plasma examples include lightning, fire, and the Aurora Borealis.

Plasma treatment is a process by which the surface of a material is modified in some way through the actions of the dissociated molecular components of a gas. Because these components are in such a high energy state, they are very chemically reactive and can easily affect changes to the surface of materials. The changes that occur are complex and dependent on many variables including gas chemistry, process pressure, and the surface chemistry of the material being processed. A key advantage to plasma treatment is that only the surface (first several molecular layers) of the material is altered; the characteristics of the bulk material remain the same.

In etching and cleaning processes, unwanted material is removed from the surface of the substrate using a relatively high energy plasma. The process breaks the contaminant molecules into smaller pieces which volatilise and are then swept out of the chamber by the vacuum pump.

Surface activation processes work by altering the first several molecular layers of the bulk material through incorporation of chemical functional groups that increase the surface energy of the material. This leads to improvements in the adhesion and wettability of the treated material.

BASIC ELEMENTS OF PLASMA TREATMENT

To plasma treat a sample in the Jupiter II, the basic steps are:

1. Place the material to be treated into the chamber.
2. Seal the vacuum chamber by closing the lid.
3. Pump the vacuum chamber down to a low, preset pressure level.
4. Introduce a process gas or gases into the chamber.
5. Apply RF energy to the low pressure gas in the chamber to light the plasma.

To end the process:

1. Stop applying RF energy to the chamber.
2. Stop the flow of process gases.
3. Bleed the chamber back to atmospheric pressure.
4. Open the vacuum chamber.
5. Remove the treated material from the chamber.

These steps are flow charted on the next page.

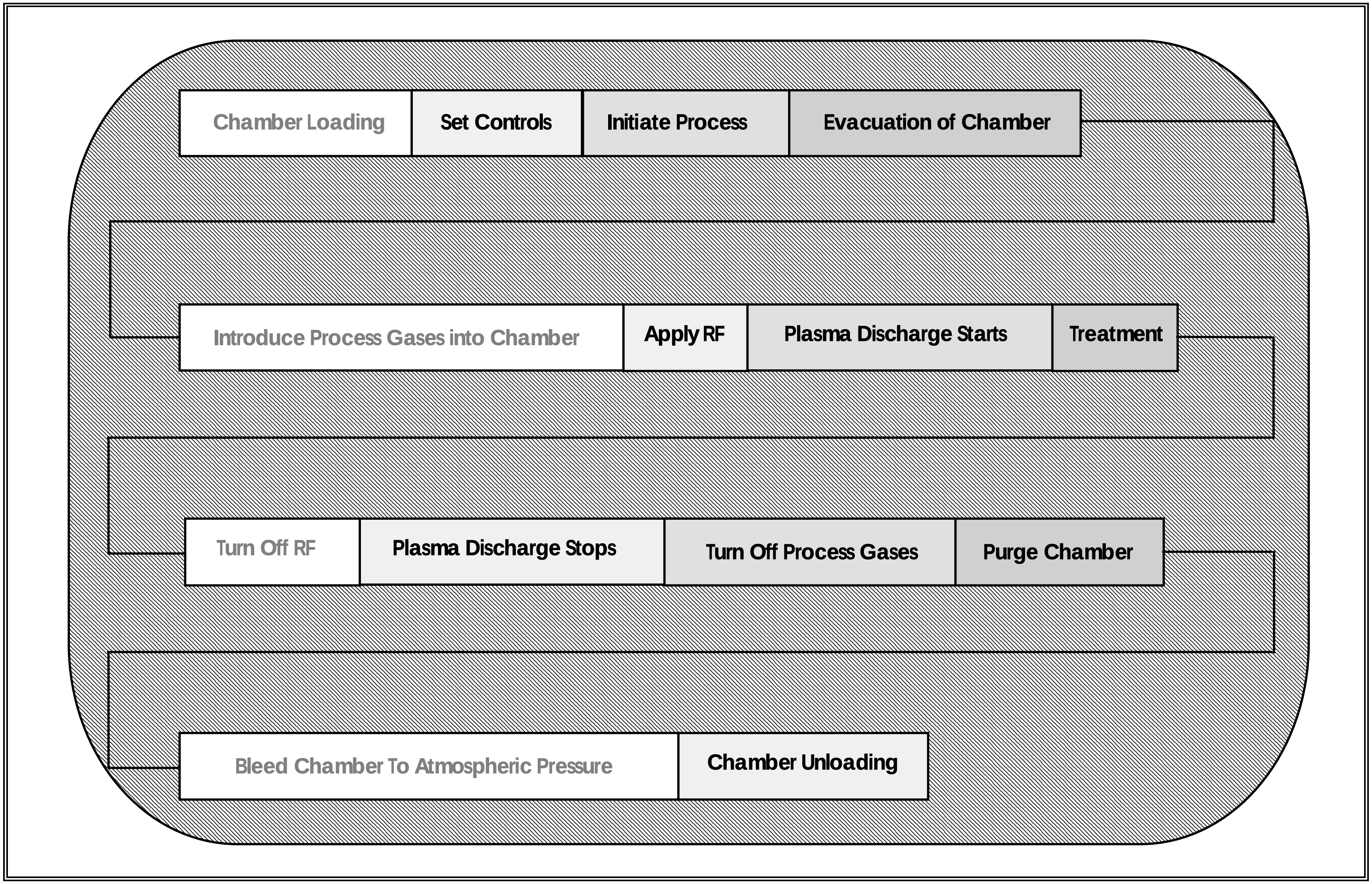
CAUTION: THE CHAMBER CAN BECOME VERY HOT DURING SOME PROCESSES. EXERCISE CAUTION TO PREVENT BURNS.

In order to develop and optimize a plasma process for a given material, the operator has the ability to alter the following parameters:

- Process gas(es) selected for use.
- Flow rate/pressure of selected gas(es).
- Amount of RF energy applied to the vacuum chamber.
- Amount of time material is exposed to the plasma.
- Vacuum chamber threshold pressure (the pressure setting that must be achieved before the process can start).

Process pressure, RF power, and treatment time are the primary factors that affect the intensity of the treatment. For example, a high energy treatment would be run under conditions of relatively low pressure, high power, and long treatment time. Conversely, a low energy treatment would be run under conditions of relatively high pressure, low power, and a short treatment time.

Since every material has different treatment requirements and many factors need to be taken into account, it is difficult to say what type of treatment will give the desired results. A general rule would be that energetic processes are better for cleaning and etching applications; more moderate processes are better for surface activation applications.



Plasma Etcher Operational Sequence

SETUP

This section illustrates the proper use of various equipment and process options.

TUNING THE RF MATCHING NETWORK

The Jupiter II Plasma System utilizes an L-C tuning network to ensure maximum transfer of energy into the chamber. The unit is equipped with a manual tuning system comprised of motor driven air capacitors which, when the system is operated in manual tuning mode, are positioned by the operator to achieve minimum reflected power during processing. This positioning is accomplished through front panel mounted switches. When running in Autotuning mode, circuitry automatically monitors the forward-to-reverse power ratio on a continuous basis during processing and positions the air capacitors for optimum power transfer to the chamber.

CAUTION: REFLECTED POWER LEVELS THAT BECOME EXCESSIVE CAN CAUSE DAMAGE TO, OR FAILURE OF, THE RF POWER GENERATOR. IT IS VITAL THAT REFLECTED POWER BE MONITORED AND KEPT TO A MINIMUM LEVEL DURING OPERATION.

Manual Tuning

- Toggle the AUTO/MAN RF tuning switch to MAN position.
- Toggle C1 and C2 switches to minimize reflected power.
- Reflected power value is displayed on the RF Power Generator.

Automatic Tuning

- Toggle the AUTO/MAN tuning switch to the AUTO position.
- Reflected power value is displayed on the RF Power Generator.
- Monitor reflected power during the plasma process to ensure proper operation of Autotuning.

ENDPOINT DETECTION

The chamber mounted UV (ultraviolet) light detector is designed for process end point determination. The detector is interfaced with the Process Controller, and functions by detecting intensity changes in the UV light emitted from the plasma. For instance, an endpoint setting of 50 percent would cause the process to terminate once the UV intensity is 50 percent of what the intensity was at the beginning of the process. This is particularly useful for cleaning applications where the UV light output becomes much less intense once all the contamination is removed.

Endpoint detection is desirable because the material of interest can be treated in the shortest amount of time necessary to achieve the desired result. This makes the plasma process more economical and reduces heat build-up in the chamber. Proper use of endpoint detection requires some trial and error on the part of the system operator in determining what the endpoint is for a specific application. The ideal endpoint setting is the highest setting that will fully treat the material. Keep in mind that the lower the endpoint setting, the longer the process will take.

To determine endpoint, place a load of untreated material in the chamber and arbitrarily choose an endpoint setting (seventy-five percent may be a good place to start). Now run the process to its completion at that endpoint setting. Analyze the treated material to determine if the treatment was satisfactory.

If the treatment is not satisfactory, reduce the endpoint setting and put in a fresh load of untreated material. The amount that the endpoint setting is reduced for this second run would depend on how well treated the parts were from the first run. If the treatment was nearly complete, a ten percent reduction in endpoint setting may be sufficient; if the treatment was not even close to complete, a thirty or forty percent reduction may be necessary.

On the other hand, if the treatment was satisfactory on the first run, it may be necessary to increase the endpoint setting in order to optimize for the shortest amount of treatment time.

Programming Endpoint

The endpoint can be set for any number from 1 to 99 percent.

To set the endpoint:

1.) Set the EP SELECT button on the Process Controller to “DETECT”.

2.) Press the + and - plunger switches on the endpoint THRESHOLD setting control to the desired setpoint.

GAS FLOW

The system is equipped with two (or an optional four) Mass Flow Controllers (MFCs). Gas channels on the Process Controller have the capacity to regulate and monitor the flow of up to 500 SCCM of nitrogen depending on the size of MFCs supplied with the unit.

Setting Gas Flow

Each gas channel has a mass flow controller, a gas flow rate control knob, and a push button activated on/off solenoid. The flow rate knob allows the flow of each gas to be set to the desired rate. The gases are mixed in a manifold before continuing on to the reaction chamber. When mixing two gases, the partial pressures of each gas in the chamber can be determined by running each gas separately prior to running the gas mixture. To do this:

1. With the system in manual operation mode, press the START button to evacuate the chamber.
2. Depress the FLOW CONTROL button for gas 1 on the PCM. The switch will illuminate and the pressure display will indicate a higher pressure due to the gas flowing into the chamber.
3. Turn the gas 1 FLOW CONTROL knob clockwise to increase gas flow. Adjust it's position to achieve the desired pressure as indicated on the pressure display.
4. Turn off the gas 1 button. Repeat steps 2 and 3 for gas 2.
5. You now have an indication of the pressure ratio of the two gas mixture.

PROCESS PROGRAMMING

This section describes the programming steps necessary for running processes in both the Manual and Automatic operational modes. Before turning on the system, refer to the Initial Start Up, page 15.

MANUAL OPERATION

When developing a process, the Manual mode is used to determine gas setting versus pressure relationships and to set the RF power level for future runs in Auto mode.

1. Check that the power level knob on the RF Generator is fully counter-clockwise.

2. Close the chamber lid.

3. Press MODE SELECT button on Process Controller to enable manual operation.

4. Toggle the AUTO-MAN tuning switch on the main system to select Autotuning.

5. Press the START button on the Process Controller to begin evacuating the chamber. Make sure process gas FLOW CONTROL buttons are set to the off position.

6. When the Pressure Display on the Process Controller reads less than 150 mTorr, press the gas FLOW CONTROL button corresponding to the desired process gas.

7. Turn the gas FLOW CONTROL knob on the Process Controller until the desired chamber pressure is achieved.

8. Press the RF ON button on the RF Generator so that the LED is lit.

9. Turn the power level knob on the RF Generator until the desired power level is displayed. A plasma should now be visible in the chamber.

10. Press the RF OFF button on the RF Generator to shut off the RF power.

11. Press AUTO/MAN button on the Process Controller to enable automatic operation. Chamber will vent to atmospheric pressure.

AUTOMATIC OPERATION

Now that the desired settings for gas flow and RF power are established, the operator can run the process in Automatic mode:

1. Set the generator up for remote operation.
   If using an RFX-600 generator:
   Press the REMOTE CONTROL button on the RF Generator so that the LED is lit. Leave the REMOTE SIGNAL button deactivated.

   If using an R300 generator:
   Turn the LOCAL/REM switch on the RF generator to REM.

   If using an R600 generator:
   Press the PROG button on the generator to enable programming options. Press the Arrow buttons until ANALOG is shown on the generator display. Turn the generator front panel dial so that ANALOG is "Enabled". Press the PROG button followed by the RUN button to back out of the programming mode.

2. Press the EP SELECT switch on the Process Controller to select "TIME" and enter the desired amount of process time into the Process Controller timer by pressing the plunger switches (labeled + and -).

   -OR-

   Press the EP SELECT switch on the Process Controller to select "DETECT" and enter the desired setting for process endpoint by pressing the plunger switches (labeled + and -).

3. Place sample of material to be treated into the chamber and close the door.

4. Press the MODE SELECT button on the Process Controller to enable Automatic operation.

5. Press the START button on the Process Controller. In the automatic mode, a sequencer will automatically:
   a) Vacuum down the chamber to the preset process threshold pressure.
   b) Start the flow of process gas.
   c) Turn on the RF power.
   d) Process the sample until the desired processing time is elapsed.
   e) Turn off the RF power.
   f) Evacuate the process gases from the chamber.
   g) Bleed the chamber back to atmospheric pressure.

6. Open chamber and remove the treated sample. For future runs in auto mode, simply press the START button.

<u>SYSTEM ABORT</u>

An automatic process can be aborted at any time by pressing the ABORT switch. This turns off the RF power and the gas flow, then vents the chamber to atmospheric pressure. If in the manual operation mode, the system must be switched to automatic mode before the chamber can be vented.

SERVICE AND MAINTENANCE

This section gives information on the warranty and details on servicing the equipment. Recommended maintenance and part replacement procedures are outlined. A trouble shooting guide is also included.

WARRANTY

1. This March system is guaranteed to be free of defects in workmanship and components. This warranty covers labor for a period of ninety (90) days and parts for a period of one (1) year, with the exception of ceramics, glass, seals, lubricants, and consumable parts such as rollers, bearings etc.

2. The exclusive remedy for any breech of this warranty is as follows: March Instruments, Inc. will furnish without charge, repairs to or replacement of those parts proven to be defective in material or workmanship. March Instruments, Inc. will issue a Return Authorization number for the defective parts. The customer will give March Instruments, Inc. a Purchase Order number of a dollar amount to cover the cost of these parts. Once the system is operational the customer will return all defective and/or unused parts back to March Instruments, Inc. with the Return Authorization number on the outside of all packages. Once these parts are received a credit will be given minus any shipping or transportation costs. No claim may be made for any incidental or consequential damages.

3. All transportation and shipping charges shall be borne by the customer.

4. March Instruments, Inc. will inspect the equipment and decide upon such repairs or replacement as are necessary. The customer will be notified of any charges incurred that are not covered by this warranty prior to undertaking those repairs.

5. Any customer modification of this equipment, or any repairs undertaken without prior written consent of March Instruments, Inc. shall render this warranty void.

6. This warranty is expressly in lieu of all warranties, expressed or implied, including implied warranty of merchantability or fitness for a particular purpose unless otherwise agreed to in signed correspondence from March Instruments, Inc. March Instruments, Inc. shall not be responsible for any damage caused by improper installation, use, servicing or testing of equipment.

NOTE: PLEASE COMPLETE AND RETURN ALL WARRANTY REGISTRATIONS RECEIVED WITH THIS SYSTEM. WARRANTY CLAIMS FOR SYSTEMS COMPONENTS SOLD BUT NOT MANUFACTURED BY MARCH INSTRUMENTS, INC. SHOULD BE PURSUED THROUGH THE DEFECTIVE EQUIPMENT'S MANUFACTURER.

SERVICING

If a March Instruments, Inc. product requires service or if technical assistance is desired, contact the Customer Service Department at 925 827 1240 (or by fax at 925 827 1189). Be prepared to provide:

- The serial number of Plasma System and all associated components.
- A detailed description of process parameters, including material being etched, gas or gases used, chamber pressure during process, RF power levels applied and duration of process.
- A detailed description of the problems encountered.

If a unit is to be returned to March Instruments for service or for any other reason, the following procedures must be followed:

- Obtain a Return Authorization number (RA) through the March Customer Service Department. Display this number on your shipping label. A unit received without an RA number visible will be rejected.
- Repack the system in its original shipping container. If this is no longer available, take special precautions to avoid damage to any glass chamber sections and other fragile components. An approved shipping container may be purchased from March Instruments.
- If the system is under warranty, you will be charged only for travel expenses and/or shipping costs. If the system is out of warranty, a purchase order will be required and you will be billed for all parts, service, shipping costs and/or travel expenses.

RECOMMENDED SPARE PARTS

The following is a list of recommended spare parts for the Jupiter II system. The location of the parts on the system is shown on the following pages.

Part Number	Quantity	Description
002-5004/002-5005	1	Focus Ring, 4”/6”
003-5009/003-5010	1	Bottom electrode disk, 4”/6”
004-7003	1	O’ring 376 Viton
004-7004	1	O’ring 345 Viton
004-7005	1	O’ring 259 Viton
004-7006	1	O’ring 240 Viton
004-7007	1	O’ring 232 Viton
007-8002	2	Coupler
008-1035	2	Fuse, 1A SLO-BLO
009-1013	1	Mass Flow Controller, 100 sccm
009-1018	2	Valve, Clippard ET-2M-12V
009-1020	1	Valve, Clippard ET-3M-12V

Above parts available in a single kit.

USER MAINTENANCE

User-performed maintenance required for Jupiter II System is minimal. However, regular attention to the suggested maintenance tasks listed below will help to ensure proper operation and maximum availability of the system. To ensure maximum performance and process repeatability, the following items should be checked at regular intervals, the frequency of which is dependent upon the level of use of the system.

CLEANING THE CHAMBER

Depending on the process, the inside of the reaction chamber may need to be cleaned regularly with isopropanol or another suitable cleaning agent. It should be noted that isopropanol is listed as a volatile organic compound and its use, even as a maintenance chemical, may be restricted by local government agencies. Use of an abrasive pad (like 3M) in conjunction with the cleaning agent is recommended except on the quartz viewport.

CAUTION: ISOPROPANOL IS A MILD SKIN AND EYE IRRITANT. USE GLOVES AND EYE PROTECTION WHEN CLEANING THE CHAMBER.

If CF4 is used as a process gas, the recommended cleaning method is to scrub the chamber with hot, soapy water and then rinse, first with DI water, then with alcohol.
After cleaning the chamber, always generate an argon or oxygen plasma for at least ten minutes at high power to remove any residual contamination.

One means of ensuring chamber cleanliness in the absence of visual indications is to:

1. Pump the chamber down to it's minimum achievable base pressure and record that value.
2. Generate an argon or oxygen plasma for fifteen minutes at high power and 400 mTorr.
3. Pump the chamber down to it's minimum achievable base pressure a second time and record that value. Compare this value to the first value. If there has been a notable decrease from the first pump-down to the second it is an indication that cleaning of the chamber has occurred while running the plasma.
4. Repeat this process until no discernible difference is noted in minimum base pressure from one test to the next.

NOTE: USE OF CF_4 OR SIMILAR GASES CAN CAUSE A COATING OF THE REACTION CHAMBER AND IT'S COMPONENTS WITH BYPRODUCTS OF THESE GASES (TEFLONS). WHEN USING THESE TYPES OF GASES IN PLASMA PROCESSES, THE CLEANING REGIMEN MUST BE REPEATED VERY FREQUENTLY TO REMOVE THE BYPRODUCTS AS THEY WILL EASILY REDEPOSIT ONTO CLEAN SURFACES OF MATERIALS THAT YOU ARE TRYING TO TREAT.

As a general rule, the chamber should be cleaned at least once a month but the frequency is very process dependent. A dirty chamber is usually obvious on visual inspection. The time to solvent clean the chamber and run a cleaning plasma should be about 30 minutes.

VACUUM INTEGRITY

It is necessary to periodically check the vacuum integrity of the system. This check should be performed only after thoroughly cleaning the chamber to avoid confusing contaminant out-gassing with vacuum leaks. The test is accomplished by completing the following steps:

1. Depress the MODE SELECT switch on the Process Control Panel to select manual mode.
2. Depress the START switch on the Process Control Panel to commence pumping down the chamber. Start timer.
3. Record the time required to reach a pressure of 100 mTorr (.10 on the display). The pressure should fall below 100 mTorr less than 5 minutes after the pressing the START button.
4. Wait 20 minutes to allow any residual moisture to exit the system and record the ultimate pressure shown on the display.
5. Turn off the nitrogen or compressed air source and disconnect the compressed gas line from the system. Press the START switch again. The vacuum valve is now closed and the chamber is isolated from the pump. If the system is not vacuum-tight, the pressure will slowly rise in proportion to the size of the leak.
6. Record the leak rate (pressure rise/minute). The system pressure should not rise more than 50 mTorr/minute (.05 on display).
7. After testing, reconnect the gas line and turn on the compressed gas source.
8. Save the vacuum check data for future reference and comparison purposes. This same procedure should be run periodically in order to recheck the vacuum integrity.

Successful operation of the vacuum system ensures optimum performance and repeatability of this system. If any discrepancies were noted during the leak-back test, inspect the chamber gasket (plastic strip around the rim of the chamber). Dirt and contaminants can sometimes build up on the gasket, compromising vacuum integrity. Also check the gas line connections on the inside and outside of the Process Controller for obvious damage or leakage.

Vacuum integrity should be checked once a month. A competent technician should be able to accomplish this task in 25 minutes.

VACUUM PUMP OIL

Many of the problems with the vacuum system are associated with the vacuum pump oil. It is important that the oil condition be checked periodically to verify that it is at the proper level and free of contaminants. Dirty or insufficient oil can result in poor vacuum pump performance. Dirty oil can also lead to possible chamber contamination due to the increased vapor pressure backstreaming into the chamber from the contaminated oil.

To change the pump oil:

1. Allow 15 minutes for the pump oil to cool slightly before beginning the operation. The pump oil should not be cold as this makes it difficult to remove from the system.

2. Vent the oil case to atmospheric pressure.
3. Disconnect the pump from the system.
4. Flush the pump with dry nitrogen to clear out any residual toxic or corrosive gases.
5. Tilt pump in the direction of the drain plug.

CAUTION: THE PUMP OIL IS A SKIN AND EYE IRRITANT. ALWAYS USE EYE PROTECTION AND APPROVED PERSONAL PROTECTIVE EQUIPMENT WHEN CHANGING THE PUMP OIL.

6. Unscrew the drain plug and drain the oil.
7. Replace the plug and run the pump for about ten seconds, leaving the inlet port open. This removes the oil from the pumping module.
8. Drain this oil by removing the plug again.
9. Replace plug and fill with fresh oil to the middle of the oil sight glass by dumping the oil into the oil fill port.

Refer to the pump manual for explicit instructions on this and all other pump procedures.

Some plasma processes may create a larger degree of pump oil contamination than others. Additional personal protective equipment may be necessary in some cases. The end user of this equipment should conduct industrial hygiene sampling in accordance with NIOSH, or other nationally recognized standards or test procedures, during the changing of the pump oil. Do not allow this pump oil to flow down the sewer drain.

Pump oil should be changed at least once a year. If the system is getting a lot of use and the process being used creates a large amount of contamination, the oil may need to be changed as often as every two months. If the pump oil appears visually dirty, it needs to be changed. Check the pump oil at least once a month. A competent technician should be able to change the pump oil in about one hour.

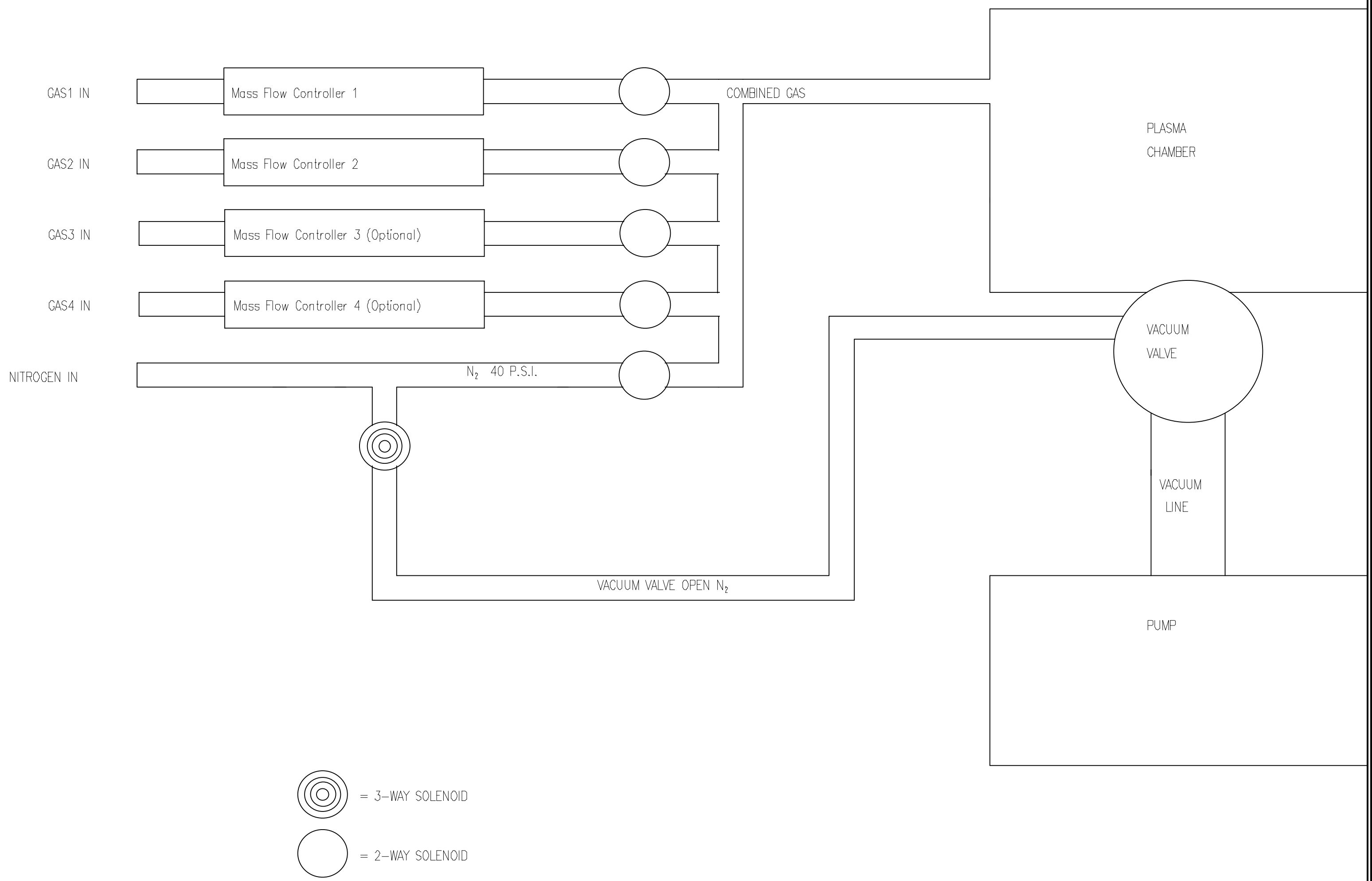
<u>VACUUM LEAK DETECTION</u>

A vacuum leak can often be detected by using isopropyl alcohol. By bathing the suspected component in the volatile liquid, a vacuum leak will suck in the vapors and cause a rise in pressure on the display panel. A rise of 10 mTorr or more would indicate a faulty vacuum component or connection. To detect small leaks, it is necessary to keep the flow of alcohol on the component or connection for approximately 10 seconds. Small leaks will not show up with a quick wetting. The flow of alcohol should cover the entire connection or component associated with the vacuum. When using the alcohol, avoid contact with the connection lettering on the back of the system as this will cause the surface to turn white and the lettering will disappear.

If the system will not pump down below 1500 mTorr, this method of leak detection may not be useful. The user will do best by following the troubleshooting chart on the following pages to locate and fix the leak.

JUPITER II MAINTENANCE CHECKLIST

DATE:									
CHAMBER CLEANING									
VACUUM CHECK									
PUMP OIL CHECK									
PUMP OIL CHANGE									



JUPITER II GAS FLOW DIAGRAM

SYSTEM TROUBLESHOOTING

This section is a troubleshooting guide for the various components in the system along with a listing of the necessary tools. The SEMI S2-93 level of hot work is also given for any maintenance procedure that must be performed with the system electrically energized.

WARNING: BEFORE BEGINNING ANY REPAIR OR MAINTENANCE RELATED PROCEDURE THAT REQUIRES REMOVAL OF EXTERNAL PANELS, DISCONNECT THE POWER AND APPLY THE APPROPRIATE LOCKOUT DEVICE TO THE POWER PLUG IN ORDER TO PREVENT REENERGIZATION OF THE EQUIPMENT.

TOOL REQUIREMENTS

The following tools will be required at one time or another to perform the troubleshooting procedures in this section. Some tools can be used in place of others, i.e. adjustable wrench in place of a 9/16 wrench.

1.) Digital Voltmeter capable of reading 0-230VDC, 0-230VAC, Continuity, and Resistance from 0-2M OHM.
2.) Watt meter capable of reading 0-1000 Watts at 13.56Mhz.
3.) Open end wrenches consisting of the following:
    3/16”, 1/4”, 5/16”, 3/8”, 7/16”, 1/2”, 9/16”, 5/8”, 11/16”, 3/4”.
4.) Allen wrench set consisting of the following:
    .050”, 1/16”, 5/64”, 3/32”, 7/64”, 1/8”, 9/64”, 5/32”, 3/16”, 7/32”, 1/4”, 5/16”.
5.) Slotted screwdriver set consisting of the following:
    1/8” X 2” blade, 3/16” W X 1 1/4” L blade, 5/32” W X 4” L blade, 1/4” W X 4” L blade, 3/16” W X 6” L blade, 5/16” W X 6” L blade.
6.) Phillips screwdriver set consisting of the following:
    #0 X 2” blade, #1 X 2 3/4” blade, #2 X 3 3/4” blade, #1 X 10” blade, #2 X 10” blade, #1 X 1 1/4” blade, #2 X 1 3/8” blade.
7.) 4” and 6” pair of wire cutters.
8.) 5” and 6 3/4” pair of needlenose pliers.
9.) 1 pair of 10” tongue and groove pliers.
10.) Nut driver set consisting of the following:
    3/16”, 7/32”, 1/4”, 9/32”, 5/16”, 11/32”, 3/8”, 7/16”, 1/2”, 9/16”.
11.) 4” adjustable wrench.
12.) 10” adjustable wrench.
13.) 1 pair of slip joint pliers.
14.) 1 pair of wire strippers capable of stripping from AWG 24 to AWG10 wire sizes.
15.) 1/4” Swagelok fitting caps, 4 ea.

DEFINITION OF HOT WORK LEVELS

These definitions apply to Hot Work Levels referred to in the following Troubleshooting and Replacement Procedures sections.

LEVEL 3: Equipment is energized. Live circuits are exposed and accidental contact is possible. Potential exposures are less than 30 volts RMS, 42.2 volts peak, 240 volt-amps, and 20 Joules.

LEVEL 4: Equipment is energized. Live circuits are exposed and accidental contact is possible. Voltage potentials are greater than 30 volts RMS, 42.2 volts peak, 240 volt-amps, and 20 Joules or RF is present.

Table 4-1. Power/Display System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
A.) Displays do not light up when AC power switch on.	1.) Power cord disconnected.	Reconnect power cord.	****
	3.) DC Power supply inoperative.	Remove Process Controller external cover. Turn on system power and on Interface PCB measure voltages at power connector P4. P4-1 =+15VDC, P4-3 = -15VDC, P4-4 =+5VDC, P4-2,5,6 = Ground. All voltages should be within .5V stated above.	LEVEL 3
	4.) Power supply electrically shorted.	With system power off and power cord removed, test for short between P4-1 and ground, short between P4-3 and ground and short between P4-4 and ground.	****
B.) Displays come on but blank out.	1.) Faulty DC power supply.	Check DC voltages at P4 of interface PCB while display is blanked out. If not present replace DC power supply.	****

Table 4-2. Vacuum System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
A.) Chamber will not evacuate in either Auto or Manual operation mode.	1.) Pump not running.	Ensure pump is plugged in and has power to it.	****
	2.) Pump oil dirty or not at correct level.	Check and replace oil as necessary.	****
	3.) Oil filter clogged.	Clean/replace oil filter.	****
	4.) Vacuum line kinked or blocked.	Remove blockage and ensure a free path from pump to system.	****
	5.) Chamber gasket faulty.	Chamber gasket should be clean and free of debris, cracks, or pitting. Separate inside and check for cracks. Replace gasket if any abnormality is detected.	****
	6.) Input nitrogen/ dry air pressure too low.	Bring nitrogen/dry air pressure to between 45 and 60 psig.	****
	7.) Faulty vacuum valve.	Repair/replace vacuum valve.	****

Table 4-2. (Continued) Vacuum System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
B.) Chamber will not evacuate to normal base pressure and system does not pass leakback check.	1.) Chamber Dirty.	Clean chamber per instructions on page 37 and perform leakback check.	****
	2.) Pump oil dirty or not at correct level.	Check and replace oil as necessary.	****
	3.) Oil filter clogged.	Clean/replace oil filter.	****
	4.) Vacuum line kinked or blocked.	Remove blockage and ensure a free path from pump to system.	****
	5.) Chamber gasket faulty.	Chamber gasket should be clean and free of debris, cracks, or pitting. Separate inside and check for cracks. Replace gasket if any abnormality is detected.	****
	6.) Leaking vacuum valve.	Shut power to pump off. Remove vacuum valve from back of chamber and disconnect it from the vacuum hose. Connect vacuum hose directly to chamber and apply power to the pump. With system in Manual, depress START switch. Let chamber evacuate for 5 minutes. If pressure reaches normal base pressure, rebuild/replace vacuum valve. If not, shut off pump and reconnect vacuum valve.	****
	7.) Leaking vacuum component or connection.	Remove system external cover. Check all connections and components associated with the chamber vacuum using the procedure outlined on page 39. Check around all feedthroughs. Replace components as needed.	LEVEL 3

Table 4-2. (Continued) Vacuum System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
C.) Chamber will not evacuate to normal base pressure and system passes leakback check.	1.) Leak between connection at vacuum valve(pump side) and vacuum pump.	Tighten all connections from vacuum valve to pump. Check connections using alcohol per procedure outlined on page 39.	****
	2.) Pump oil dirty.	Replace pump oil.	****
	3.) Pump oil too low or too high.	Add/remove oil to bring within specifications.	****
	4.) Faulty pump.	Replace pump.	****

Table 4.3 Gas System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
A.) Process gas does not appear to flow into chamber, as indicated by increase in chamber pressure (If in Auto mode, try checking gas flow in Manual mode of operation).	1.) Gas bottle empty.	Replace gas bottle.	****
	2.) Gas turned off.	Turn gas on.	****
	3.) Process gas not regulated to 15-20 psi.	Regulate gases properly.	****

Table 4.4 RF System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
A.) RF power does not turn on.	1.) Generator control cable faulty or not plugged in tight.	Using digital multimeter measure for continuity from Pin 1 at the 15 Pin connector end to Pins 3 and 4 on the 25 Pin connector end. If no continuity, repair cable. If continuity, install cable at system. On main system, turn on power and select Manual operation. Depress the START switch. When chamber is around 200 mTorr, activate gas flow. Connect common lead of multimeter to chassis ground and plus lead to pin 3 or 4 on the 25 pin connector end of the generator control cable. Depress the RF ON switch on the generator display panel. Continuity should be read on the meter when the RF ON switch is depressed. If continuity is not read replace Interface PCB. If continuity is read the RF generator is suspect.	****

Table 4.4 (Continued) RF System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
A.) (Continued)	2 .) Faulty RF generator.	Turn on power to system. On the display panel select Manual operation and press START switch. Evacuate the chamber to approx 200 mTorr then activate gas flow. Remove generator control cable from the RF generator and install the generator test plug. Depress the REMOTE CONTROL and REMOTE SIGNAL switches on the RF generator to the off position then depress the POWER switch on. A green INTLK lamp should be lit under the Left Display on the generator. If not, generator is faulty. If so, turn the LEVEL knob fully counter clockwise. On the main system, ensure the AUTO/MAN tuning toggle switch is in the AUTO position. Depress the RF ON switch on the generator. FWD PWR and REFL PWR displays should read zero. Depress and hold the SETPOINT switch and adjust the LEVEL knob for 300 Watts. Release the SETPOINT switch. The FWD PWR should read 300 Watts and REFL PWR should read no higher then 5 Watts and a plasma should be seen in the chamber. If, while depressing the SETPOINT switch, the LEVEL knob had no control then generator is faulty. If no FWD or REFL power was displayed on the Left and Right displays after releasing the SETPOINT switch and the SETPOINT indicator lamp is flashing then generator is faulty.	****
	3.) No time value set on process timer.	Set a time value on the timer.	****
	4.) RF generator not turned on.	Turn on main power on generator and make sure circuit breaker on the back of the unit is on also.	****
	5.) REMOTE CONTROL and REMOTE SIGNAL buttons on RF generator are improperly set.	Manual system operation: Disable both buttons. Automatic System Operation: Enable REMOTE CONTROL, disable REMOTE SIGNAL.	****
B.) System not Autotuning (If system will not Autotune, try Manual tuning).	1.) Loose or broken motor couplers.	Shut power to pump off and disconnect vacuum valve on chamber side of valve. Remove system external cover. Turn on main power to the system. Place the AUTO/MAN tuning toggle switch in the MAN position. While observing the tuning network capacitors inside of the system enclosure, hold the C1 switch in the down position. The top capacitor should rotate one direction.	****

Table 4.4 (Continued) RF System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
B.) (Continued)		Hold the C1 switch in the up position. The top capacitor should rotate in the opposite direction. Do the same check using the C2 switch while observing the lower capacitor. If either capacitor does not rotate both ways, check motor couplers for tightness at the shaft of the capacitor and shaft of the motor. Also check for broken coupler. Replace as necessary.	
	2.) Phase/Magnitude module (located within system enclosure at the RF cable connection) is not securely connected to the wiring harness.	Tighten the connection.	****
	3.) Phase/Mag module needs adjustment/alignment.	Follow procedure outlined in Tuning and Replacement Procedures, page 53.	LEVEL 4
	4.) Chamber pressure is not between 100 and 1200 mTorr.	Bring chamber pressure within acceptable limits.	****

Table 4-5. Bleed System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
A.) System will not bleed back to atmospheric pressure when the ABORT switch is pressed.	1.) Bleed valve failure.	Replace bleed valve.	****
	2.) Vacuum valve failure.	Replace vacuum valve.	****
	3.) System is not in AUTO operational mode.	Switch system to AUTO mode.	****

TUNING AND REPLACEMENT PROCEDURES

The following section describes the various tuning and replacement procedures that may be necessary for the Jupiter II system.

CAUTION: THESE CAUTIONS ARE APPLICABLE TO THE ACTIONS DETAILED ON THE FOLLOWING PAGES:

- **LINE VOLTAGE HAZARD EXISTS WHEN THE EXTERNAL PANELS ARE REMOVED.**
- **RADIO FREQUENCY VOLTAGE AND EXPOSURE HAZARD EXISTS WHEN THE EXTERNAL PANELS ARE REMOVED.**
- **HIGH TEMPERATURE BUILDUP WILL OCCUR ON SOME ELECTRONIC COMPONENTS AND HEAT SINKS INSIDE THE EXTERNAL PANELS DURING OPERATION.**

THE RF SYSTEM

This portion of the manual provides information necessary to perform Maintenance, Fault Isolation, and Removal and Replacement of subject assemblies in the RF system. It also details Adjustments required for proper operation.

Fundamentals of Operation

Autotuning circuitry consists of an RF Phase and Magnitude sensing device, a Tuning Controller and associated wiring. The RF Phase and Magnitude sensing device measures forward and reverse power magnitudes and phase relationships of the RF as it is applied to the tuning network. Phase of the RF power is measured at two points; magnitude is similarly measured. The measurement at one point is compared to that at the other point. If any difference exists, it is output as a voltage to the amplifiers on the tuning controller printed circuit board. Here it is amplified to a level sufficient to drive the tuning motors which control the positioning of the variable capacitors of the tuning network. When these capacitors are properly positioned, there will be minimal standing waves in the RF transmission lines which will result in little or no difference in the value of the phase or magnitude of the RF when measured at the two sensing points. This, in turn, results in a zero volt difference between these points. No drive voltage for the tuning motors is created and the tuning capacitors will retain their position until the tuning degrades. When this occurs, the phase/magnitude sensor will detect the difference, and express it as a voltage, which will be amplified by the tuning controller amplifiers for application to the tuning capacitor motors and drive the tuning capacitors to values capable of most effectively coupling the RF power to the plasma.

When the Automatic/Manual Tuning switch on the control panel of the unit is placed in the AUTO position, the output of the amplifiers on the tuning controller PCB are applied to the tuning capacitor positioning motors. When the same switch is placed in the MANUAL mode, the operator controls tuning by applying a drive voltage of + or - 15V to the individual drive motors through switches C1 & C2. By monitoring reverse (or reflected) power via the RF Meter on the control panel of the unit the operator can manually tune for a minimum reverse power level.

Maintenance

No regular maintenance is required.

Fault Isolation

The following procedure is to be used in determining the cause of problems with the components in the RF system.

Hot Work Level 4

Required Materials:

- Multimeter
- Standard assortment of hand tools (See list on page 42)

Procedure

1. Using standard operational procedures and process parameters, run plasma system through normal operational cycle.
2. Observe forward power indication on RF Level meter. It should be possible to obtain an indication of the maximum level that the RF generator installed in the system is capable of achieving. The unit should be manually tuned for minimum reverse power as indicated on the RF Level meter. If it is not possible to manually tune the unit for a reverse power level of 5 watts or less, proceed no further. Contact March Instruments to arrange for factory reconfiguration of the tuning network.
3. Once unit is manually tuned properly, place the control panel mounted tuning mode selection switch in the AUTO position. The system should maintain approximately the same low value of reverse power as indicated on the RF level meter. The unit may temporarily go out of tune when switching from Manual to Automatic tuning but will return to a tuned condition after a few seconds. This is normal and expected. If the unit remains out of tune for more than 30 seconds, return to manual tuning and tune unit or turn off RF to prevent damage to the power amplifier.
4. Increase and decrease chamber pressure by adjusting gas flow. The unit should maintain approximately the same low value of reverse power as indicated on the RF level meter.
5. Increase and decrease RF power level by RF generator output. The system should maintain approximately the same low value of reverse power as indicated on the RF level meter.
6. Place the control panel mounted tuning mode selection switch in the MAN position. Actuate C1 & C2 to detune the unit. This is indicated by a dimming or extinguishing of the plasma glow and an increase in the value of reverse power as indicated on the RF level meter or a sounding of the tuning alarm.
7. Once unit is detuned, place the control panel mounted tuning mode selection switch in the AUTO position. The system should tune to and maintain the original low value of reverse power as indicated on the RF level meter.
8. If the unit passes all of the steps detailed above, it is operational. If it fails any of those steps, continue with steps listed below.
9. Ensure unit power has been turned off. Remove AC Line power cord if possible.

10. Remove system external enclosure.
11. Visually inspect RF Tuning Controller PCB for evidence of burning, shorting or damaged components. If any evidence of damage is noted, repair or replace the printed circuit board or failed components on that board. Inspect all wiring and connections for mechanical and electrical integrity. Repair as necessary.
12. To determine proper output from Phase/Mag module, disconnect wiring harness from Phase/Mag module and connect test equipment as shown in Diagram 1. Set meter to 2 volt scale (or closest setting).

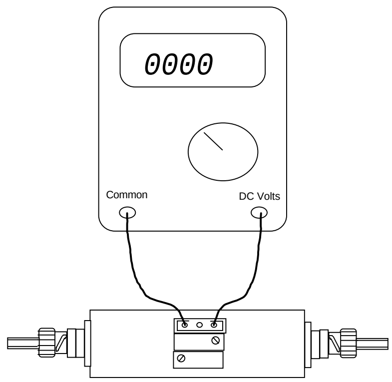


Diagram 1.

NOTE: IT IS NECESSARY TO DETERMINE WHICH PIN ON THE PHASE/MAG MODULE IS AT GROUND POTENTIAL. WHILE IT WILL ALWAYS BE ONE OF THE TWO OUTSIDE PINS, A SMALL PERCENTAGE OF PHASE/MAG MODULES WERE CONSTRUCTED WITH THE NORMAL PIN ASSIGNMENT(AS ILLUSTRATED IN THE ABOVE AND FOLLOWING DIAGRAMS) REVERSED. TO DETERMINE GROUND PIN ASSIGNMENT, CHECK FOR CONTINUITY BETWEEN ETCHER CHASSIS AND OUTSIDE PINS. IF PIN ASSIGNMENT IS REVERSE OF THAT ILLUSTRATED, THEN REVERSE MULTIMETER CONNECTIONS TO MATCH.

13. Reconnect AC power cord if removed.
14. Using standard operational procedures and process parameters, run plasma system through normal operational cycle.
15. Allow unit to warm up for at least one minute before taking readings.
16. Multimeter should indicate a -.5 volt to +.5 volt swing when adjusting lower potentiometer from one end of it's travel to the other. If this range cannot be obtained, replace the Phase Magnitude module. See Adjustment procedures (page 53) for proper setting of potentiometers.
17. Turn off RF power.

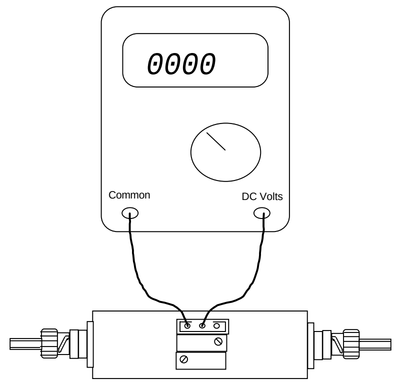


Diagram 2.

18. Connect test equipment as shown in Diagram 2. Set meter to 50 millivolts scale (or closest setting).
19. Using standard operational procedures and process parameters, run plasma system through normal operational cycle.
20. Multimeter should indicate a -.5 volt to +.5 volt swing when adjusting upper potentiometer from one end of it's travel to the other. If this range cannot be obtained, replace the Phase Magnitude module. See Adjustment procedure (page 53) for proper setting of potentiometers.
21. If output of Phase/Magnitude Module is correct, check inputs to and outputs from Tuning controller PCB. Inputs on J1-7 & J1-8 should be equivalent to outputs from Phase Magnitude module. Outputs of Tuning Controller, measured at IC1, pins 1 & 7, should be equivalent to outputs from Phase Magnitude module amplified by up to a factor of 50. Other Tuning Controller inputs to test include:

Location	Voltage
Connector J1 Pin 3	GROUND
Connector J1 Pin 6	GROUND
Connector J2 Pin 1	-12 VDC
Connector J2 Pin 2	+12 VDC

22. If inputs to the Tuning Controller PCB are correct, yet outputs are incorrect, replace Tuning Controller PCB.
23. If unit will tune in one mode but not the other, and outputs are correct from both Phase/Magnitude module and Tuning Controller PCB, check tuning mode selection switch (marked AUTO MAN) for continuity.

<u>Removal and Replacement of the Phase Magnitude Module</u>

The following lists the steps necessary for the removal and replacement of the Phase Magnitude module.

Required Materials:

- Standard assortment of hand tools (See page 42)

Procedure

1. Ensure unit power has been turned off and the power cord disconnected.

2. Remove Chamber module external enclosure.
3. To remove Phase Magnitude module, disconnect wiring harness from Phase/Magnitude module by removing connector plug from socket.
4. Disconnect RF cable from both sides of Phase/Magnitude module by removing BNC connector plugs from connector sockets.
5. Loosen screws securing Phase/Magnitude module to chassis of unit.
6. To reinstall, reverse steps 2 through 5 above.

Adjustment of the Phase/Magnitude Module

The following lists the steps required to adjust the Phase/Magnitude module.

Hot Work Level 4

Required Materials:

- Multimeter
- Standard assortment of hand tools (See page 42)

Procedure

1. Remove Chamber module external enclosure.
2. Using standard operational procedures and process parameters, run plasma system through normal operational cycle.
3. Observe forward power indication on RF Level meter. It should be possible to obtain an indication of the maximum level that the RF generator installed in the system is capable of achieving. The unit should be manually tuned for minimum reverse power as indicated on the RF Level meter. If it is not possible to manually tune the system for a reverse power level of 5 watts or less, proceed no further. Contact March Instruments to arrange for factory reconfiguration of the tuning network.

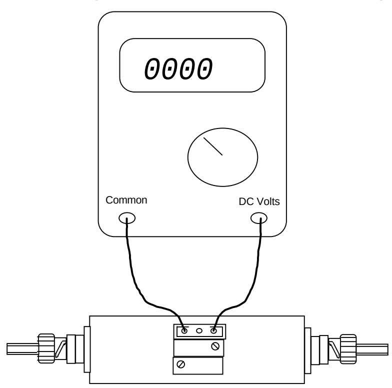


Diagram 3.

NOTE: THE RF GENERATORS USED WITH MARCH PLASMA SYSTEMS ARE EQUIPPED WITH CUTBACK CIRCUITRY TO PREVENT DAMAGE IN CASE OF SEVERE IMPEDANCE MISMATCHES. AS THE MISMATCH BECOMES MORE SEVERE, FORWARD POWER IS CUT BACK TO PREVENT DANGEROUS CURRENT AND VOLTAGE LEVELS (WHICH COULD CAUSE FAILURE OF THE POWER AMPLIFIER) FROM BUILDING UP.

4. Turn off RF power.
5. To adjust output from Phase/Mag module, disconnect wiring harness from Phase/Mag module and connect test equipment as shown in Diagram 3. Take care to avoid physical contact. Set meter to 2 volt scale (or closest setting).
6. Turn on RF power.
7. Taking care not to come into contact with any RF transmission line, tuning network component, or chamber electrode, adjust the lower potentiometer on the Phase/Mag module so that the Multimeter indicates zero volts (+/- 5 millivolts).
8. Turn off RF power.
9. Connect test equipment as shown in Diagram 4. Set meter to 2 volt scale (or closest setting).

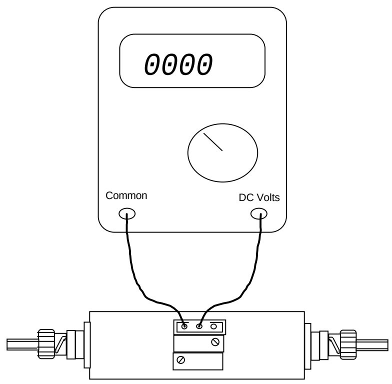


Diagram 4.

10. Turn RF on.
11. Adjust the upper potentiometer on the Phase/Mag module so that the Multimeter indicates as closely as possible to zero volts (+/- 5 millivolts).
12. Turn off RF power.
13. Repeat steps 6-11 above until both pins on the Phase/Mag module indicate as closely as possible to zero volts (+/- 5 millivolts).
14. Turn off unit power.
15. Disconnect Multimeter and reattach wiring harness to Phase/Mag module.
16. Test unit for proper operation as detailed in <u>Fault Isolation</u>, page 50, steps 1 through 8. If unit does not pass these tests, recheck adjustment and repeat if necessary.
17. When adjustment is complete, replace external enclosure.

CONSUMABLES

The only consumable is used in the system is the fluorinated pump oil (Krytox). This pump oil can become corrosive after being exposed to certain process gases. Always wear approved personal protection equipment (eye protection and rubber gloves) when changing the pump oil. Waste oil and any dirty rags generated during maintenance should be considered hazardous waste. It should never be dumped down the drain. Instead, place the oil in a corrosion proof waste container and dispose of the waste container at an EPA certified waste disposal company when full.

The Material Safety Data Sheet has been included in the back of the manual for reference.

APPENDIX

The appendix contains information on various elements of plasma processing with the Jupiter II equipment. Instructions on process development for etching applications and optimizing pump down speed are included.

PUMP DOWN SPEED

Additional vacuum hose length, greater inner diameter, and increased number of bends will all contribute to an increase in pump-down times. For best results, position the vacuum pump as close to the chamber as possible and use flexible tubing to minimize effect of sharp bends.

PROCESS DEVELOPMENT-ETCHING

Etching processes can be controlled by the operator of the equipment to achieve desired characteristics including:

- Etch Rate.
- Uniformity.
- Anisotropy.
- Selectivity.

Associated characteristics can be controlled as well, including:

- Process Heat.
- Ion Exposure.

Control is achieved through selection of:

- Process Gas Type.
- Process Gas Flow.
- RF Power Level.
- Chamber Pressure.
- Process Cycle Time.

The matrix on the following page is intended as a general guideline to help the operator develop an etching process by manipulating the system variables. It must be noted that the plasma etching process is extremely complex and is not easily characterized. In offering this information, March Instruments makes no claim as to it's applicability in tailoring operator controllable parameters to achieve specific etch characteristics. It is offered only to illustrate how altering an operator controllable parameter might effect an etch characteristic.

	Gas Choice	Gas Flow	RF Power	Process Time	Pressure	Chamber Loading
Etching Characteristics:						
Uniformity Increased	Yes	+/-	+/-	No Effect	+/-	-
Uniformity Decreased	Yes	+/-	+/-	No Effect	+/-	+
Etch Rate Increased	Yes	+/-	+	+	+/-	-
Etch Rate Decreased	Yes	+/-	-	-	+/-	+
Anisotropy Increased	Yes	+/-	+	-	-	Unknown
Anisotropy Decreased	Yes	+/-	-	+	+	Unknown
Selectivity Increased	Yes	+/-	+/-	No Effect	+/-	Unknown
Selectivity Decreased	Yes	+/-	+/-	No Effect	+/-	Unknown
Heat Build-up Increased	Yes	-	+	+	-	+
Heat Build-up Decreased	Yes	+	-	-	+	-
Ion Exposure Increased	Yes	+/-	+	+	+	Unknown
Ion Exposure Decreased	Yes	+/-	-	-	-	Unknown
Process Cycle Time Increased	Yes	+/-	-	+	+/-	+
Process Cycle Time Decreased	Yes	+/-	+	-	+/-	-

(+) =Increase value of parameter for desired change (+ / -) = Value of parameter can be increased or decreased for desired change

(-)=Decrease value of parameter for desired change

AVOIDING PROCESS GAS LINE CONTAMINATION

Process gas lines can be contaminated with air whenever the connection between the gas source and the plasma system is broken. This occurs when changing gas cylinders or mass flow controllers, or when swapping gas lines.

Air contamination in gas lines displaces the desired process gas. This can result in inconsistent processing results and/or poorly treated product. This becomes especially critical in the smaller systems due to the small size of the mass flow controllers (the low flow rates prevent air contamination from being flushed out of the lines quickly).

PREVENTIVE MEASURES

In order to avoid contaminating the lines, March recommends the following preventive steps.

Swapping Gas Lines:

When gas lines are swapped, no contamination will result as long as the gas connectors are “quick connect”. If quick connects are not used, a needle valve should be in place which can be closed to isolate the gas line.

Changing Mass Flow Controllers:

When changing mass flow controllers, always be sure to first isolate the gas line by removing the “quick connect” or closing the needle valve.

Changing Gas Cylinders:

1) Close valve on gas cylinder.
2) Close valve on gas regulator to isolate gas line.
3) Disconnect gas cylinder from gas regulator.
4) Connect new cylinder to regulator.
5) Open valve on gas cylinder.
6) Open valve on gas regulator.

Gas Line Integrity:

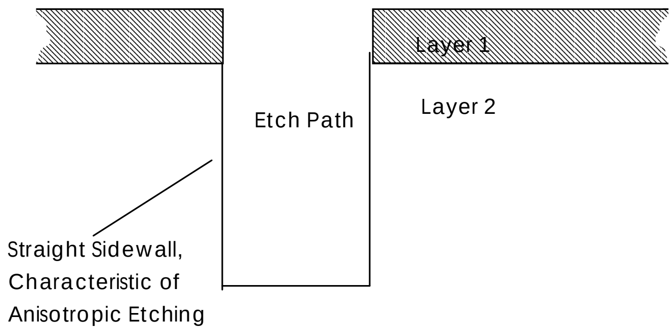
Take care to insure that gas lines do not leak. Gas line integrity can be confirmed simply by opening the valve on the gas cylinder then quickly closing it again. If the pressure reading on the regulator drops within one minute, there is a substantial leak that may result in air contamination.

Gas leaks can be located using a soap/water solution (commercially available under the brand name Snoop). With the gas cylinder and regulator valves open, inundate areas of suspected leakage. Soap bubble formation indicates a gas leak.

GLOSSARY

The following lists definitions of commonly used terms in this manual.

Anisotropic: Etching that is directional in it's action with characteristic etch path side walls that are perpendicular to the electrode plates of the etcher. Characteristic of etching applications where the preservation of underlying material is desirable. Typical of reactive ion etchers(RIE).



Autotuning System: The system that automatically tunes the RF matching network for minimal reflected power so that there is optimal power transfer to the chamber.

Base Pressure: The preset pressure, factory programmed, at which the plasma process begins. The lower the Base Pressure level, the less impurities will be present in the chamber when the process gas is introduced. By evacuating the chamber for a longer or shorter period of time at the commencement of the process cycle, more or less of the room air and water vapor present in the chamber will be pumped out before the process gas is introduced. Also referred to as **Process Threshold Pressure**.

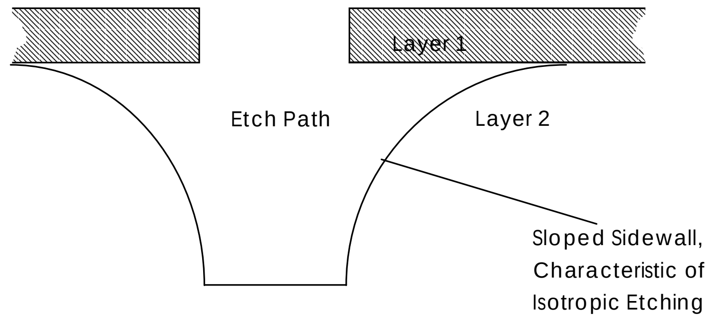
Clippard Valve: A brand of solenoid valve used in the Jupiter II system.

Endpoint: The point at which a material has received satisfactory treatment. Most commonly used in reference to cleaning processes.

Etch Rate: The rate at which material is removed during exposure to plasma. Often given as a value of Angstroms per minute.

Forward Power: The amount of RF energy applied to the plasma. This value is measured in watts.

Impedance Matching: The matching of the fixed output impedance of the RF Power Generator to the constantly varying input impedance characteristic of a plasma. This is done to attain maximum transfer of available RF energy to the plasma and keep the plasma uniform.



Isotropic: Etching that is not directional in it's effect. Characteristic of most cleaning applications where it is desirable to remove material from all surfaces. Typical of barrel type etchers.

Leak-back Rate: The rise in pressure versus time for an evacuated chamber that has been isolated from the vacuum source. A measurement of the magnitude of a vacuum leak. While a certain amount of leakage is to be expected, excessive leakage is detrimental to the performance of the equipment.

Matching Network: The module in the plasma system that accomplishes the matching of the fixed output impedance of the RF Power Generator to the constantly varying input impedance characteristic of a plasma.

Optical Endpoint Detection: The monitoring of light emitted by the plasma to determine the progress of the plasma etching or cleaning cycle. As treatment commences, UV(Ultraviolet) light of a wave length specific to the material being removed is given off. As the process continues the amount of material being etched away decreases, as does the emitted light. As the etching process nears completion, there is less material to etch so the light being emitted decreases. Optical Endpoint Detection monitors this phenomenon via a UV detection device and circuitry in the Process Controller determines the difference between peak light emission and emission at any point in the process; the user can select a percentage of peak light emission as a stop point for processing. When this percentage is reached the machine will undergo a normal end of process sequence.

Parameter: A variable in the plasma process that can be changed by the operator. A value chosen for the specific parameter is passed to a controlling device in the plasma system which will then regulate the plasma generation process accordingly. For example, RF Power Level is a parameter; a typical value assigned to this parameter would be 300 watts.

Plasma: A highly energetic state of matter produced when a gas is introduced into a chamber at low pressure and is excited by the application of RF energy. This results in a disassociation of the gas molecules into ions, free radicals and other reactive species which interact physically and chemically with exposed surfaces of materials.

Process: The plasma cycle. The complete sequence of steps a material is subjected to in order to attain desired results. A process can consist of single or multiple programs.

Process Recipe: A sequential listing of the total set of conditions which make up a process. This includes gas type and process parameters as well as sample loading and positioning in the treatment chamber.

Process Threshold Pressure: The preset pressure, factory programmed, at which the plasma process begins. The lower the Process Threshold Pressure level, the less impurities will be present in the chamber when the process gas is introduced. By evacuating the chamber for a longer or shorter period of time at the commencement of the process cycle, more or less of the room air and water vapor present in the chamber will be pumped out before the process gas is introduced. Also referred to as **Base Pressure**.

Program: A listing of all parameters which are entered into the process controller by the operator. A program can be a complete process in the case of a one step process, or a single step in a process that requires multiple steps. A basic program would include values for Gas Flow, Process Time, and RF Power Level.

Pump-down Speed: The amount of time required to reach Base (Threshold) Pressure once the chamber is placed under vacuum.

Radio Frequency(RF): The frequency range of the power generators used to create the plasma in the Jupiter II equipment. The specific frequency is 13.56 MHz.

Reactive Ion Etching(RIE): A high energy plasma process used to remove relatively large quantities of material. Due to high energy ion bombardment, material to be etched can be removed quickly.

Read point: Actual value of a parameter at any given time as monitored by that parameter control device's sensors and reported for the operator's information on the appropriate panel display.

Reflected Power: The amount of RF energy that is not successfully transferred to the plasma, due to an impedance mismatch. May also be referred to as **Reverse Power**.

Reverse Power: The amount of RF energy that is not successfully transferred to the plasma, due to an impedance mismatch. May also be referred to as **Reflected Power**.

Selectivity: Different materials have different etch rates when exposed to the same plasma. This phenomenon can be manipulated to control, through process parameter selection, the etch rate of separate components of a multiple substance device to preserve one material while removing another.

Set point: The value of a parameter set in the Process controller. Once set, the Process Controller will keep the parameter at the set point throughout the course of the process.

Threshold Pressure: The preset pressure, factory programmed, at which the plasma process begins. The lower the Process Threshold Pressure level, the less impurities will be present in the chamber when the process gas is introduced. By evacuating the chamber for a longer or shorter period of time at the commencement of the process cycle, more or less of the room air and water vapor present in the chamber will be pumped out before the process gas is introduced. Also referred to as **Base Pressure**.

Tuning: The process of controlling the settings of the tuning network components to effect best possible impedance matching. This can be performed through manual input from the operator or through an automatic function, whereby forward and reverse power levels are compared and a feedback is generated from that comparison which is used to set the value of the variable components.

Tuning network: A coupling network by which impedance matching is controlled and optimized by varying the phase and amplitude of the RF waves entering the treatment chamber. Alteration of these values compensates for any mismatch in impedance as the network couples the RF power to the chamber.

Ultimate Pressure: The highest chamber vacuum level achievable, as indicated by observation of the chamber pressure after it has been subjected to vacuum for a period of time sufficient for the pressure reading to completely stabilize. The capacity of the vacuum pump, the dimensions of the connecting line between the vacuum pump and the chamber, and the overall vacuum integrity of these components all affect the achievable Ultimate Pressure.

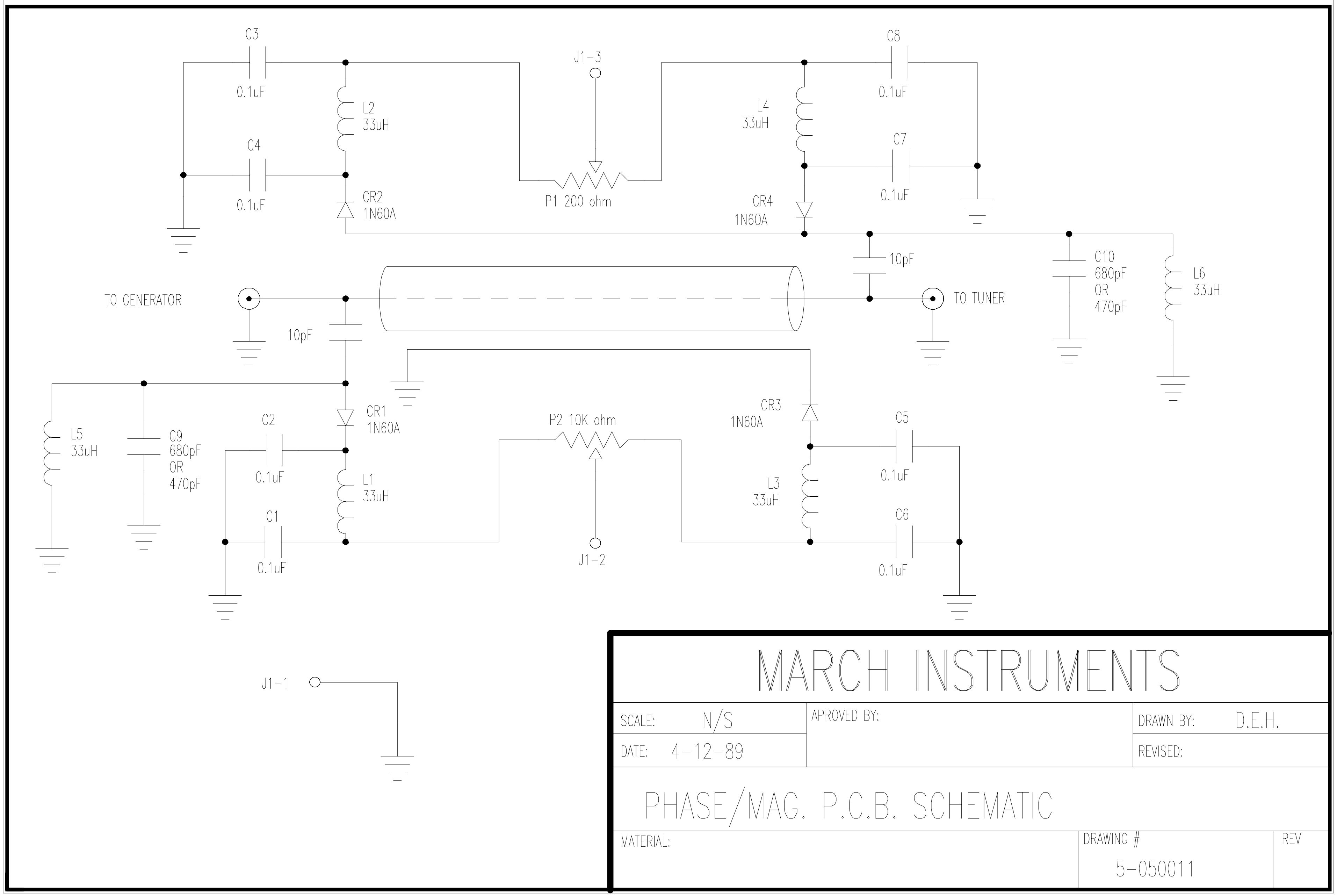
Ultraviolet (UV) Light: The region of the electromagnetic spectrum just beyond the visible wavelengths. The plasma environment is rich in UV light and this is one of the elements contributing to the surface modifications created by plasma.

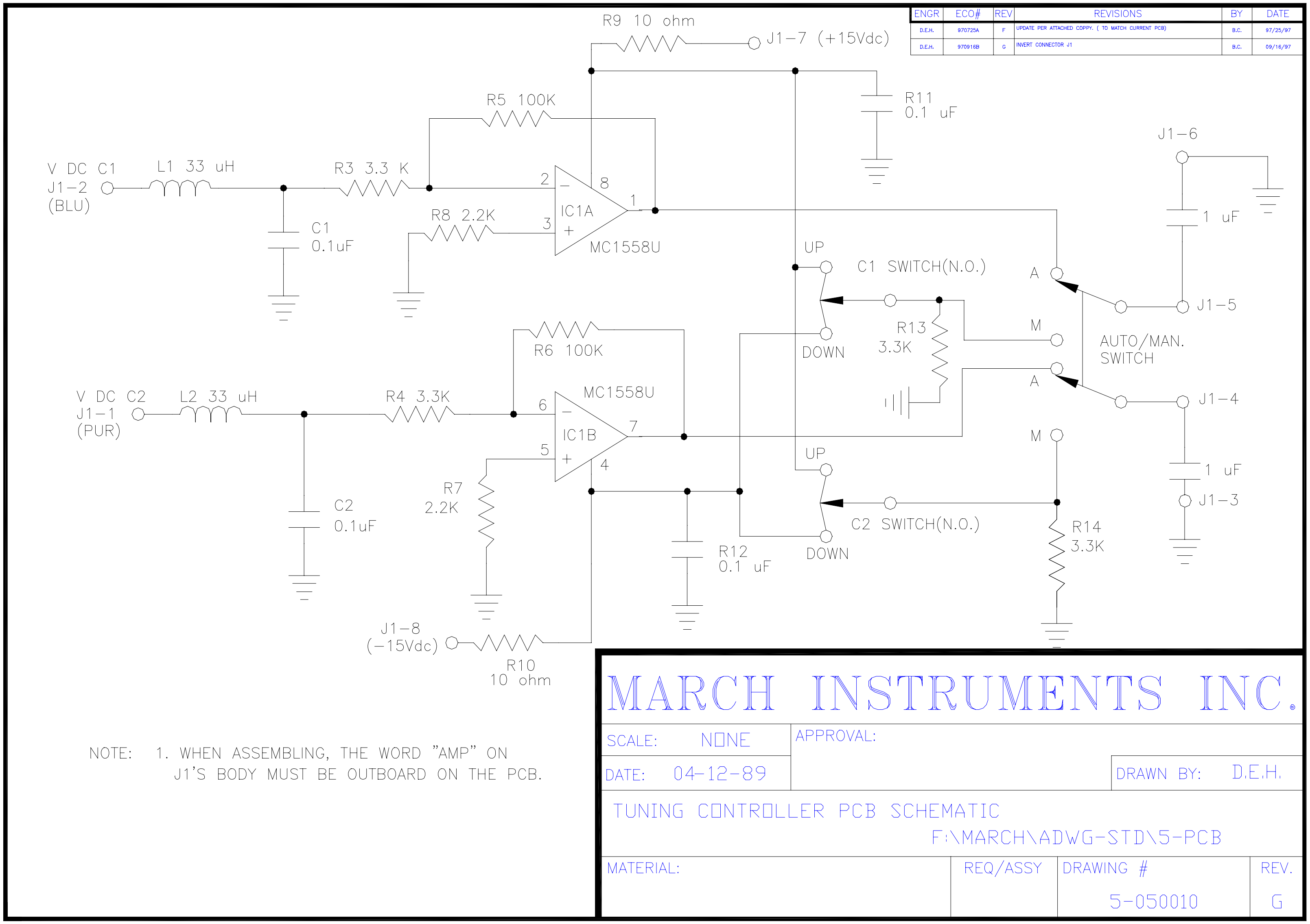
Uniformity: The degree to which the plasma process gives a uniform treatment across a materials surface. Also can refer to the degree plasma uniformity inside the chamber.

NOTES

SCHEMATICS

The following pages are the schematics for components of the Jupiter II system. Included are schematics for the Process Control Module, PCM Control PCB, Tuning Controller PCB, Phase Mag. PCB, and overall system.


C3
0.1uF
C4
0.1uF
L2
33uH
CR2
1N60A
J1-3
P1 200 ohm
C8
0.1uF
L4
33uH
C7
0.1uF
CR4
1N60A
10pF
C10
680pF
OR
470pF
L6
33uH
TO GENERATOR
TO TUNER
10pF
L5
33uH
C9
680pF
OR
470pF
CR1
1N60A
C2
0.1uF
L1
33uH
C1
0.1uF
P2 10K ohm
J1-2
CR3
1N60A
C5
0.1uF
L3
33uH
C6
0.1uF
J1-1
MARCH INSTRUMENTS
SCALE: N/S
APROVED BY:
DRAWN BY: D.E.H.
DATE: 4-12-89
REVISED:
PHASE/MAG. P.C.B. SCHEMATIC
MATERIAL:
DRAWING # 5-050011
REV



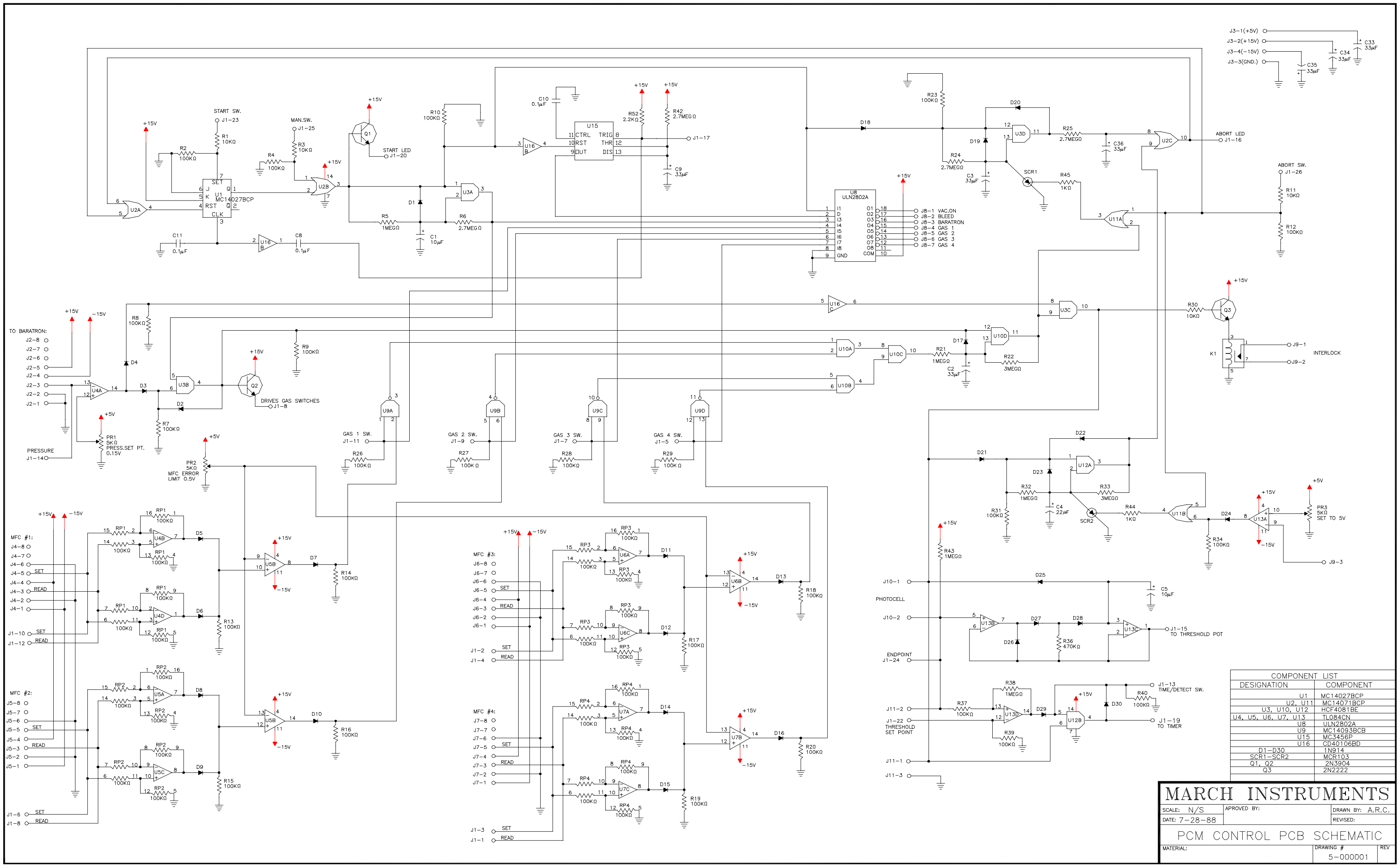
ENGR	ECO#	REV	REVISIONS	BY	DATE
D.E.H.	970725A	F	UPDATE PER ATTACHED COPPY. (TO MATCH CURRENT PCB)	B.C.	97/25/97
D.E.H.	970916B	G	INVERT CONNECTOR J1	B.C.	09/16/97

MARCH INSTRUMENTS INC.

SCALE: NONE
APPROVAL:
DATE: 04-12-89
DRAWN BY: D.E.H.

TUNING CONTROLLER PCB SCHEMATIC
F:\MARCH\ADWG-STD\5-PCB

MATERIAL:
REQ/ASSY
DRAWING # 5-050010
REV. G



COMPONENT LIST

DESIGNATION	COMPONENT
U1	MC14027BCP
U2, U11	MC14071BCP
U3, U10, U12	HCF4081BE
U4, U5, U6, U7, U13	TL084CN
U8	ULN2802A
U9	MC14093BCB
U15	MC3456P
U16	CD40106BD
D1–D30	1N914
SCR1–SCR2	MCR103
Q1, Q2	2N3904
Q3	2N2222

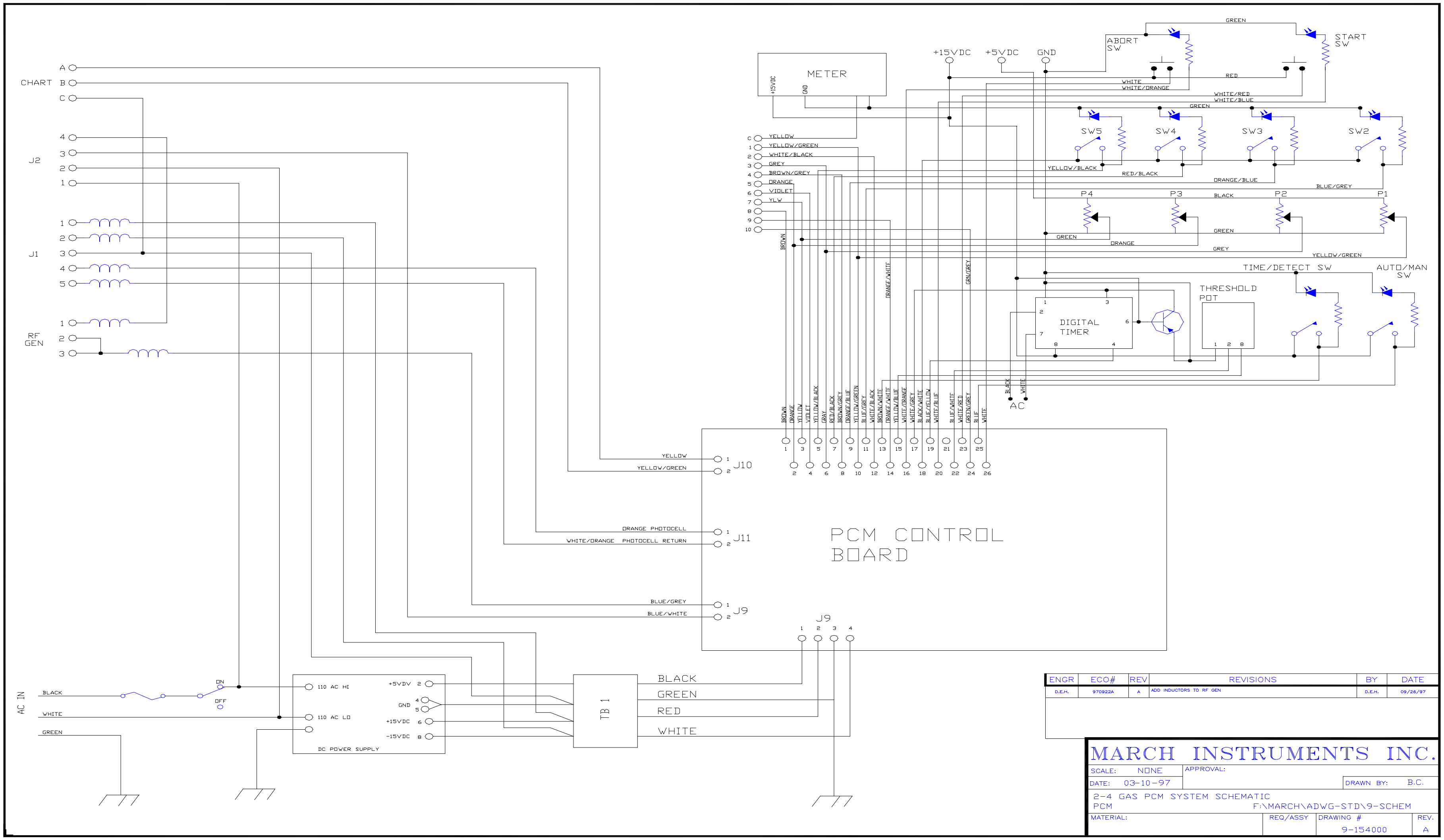


CHART
J2
J1
RF GEN
AC IN
BLACK
WHITE
GREEN
ON
OFF
110 AC HI
110 AC LO
+5VDV
GND
+15VDC
-15VDC
DC POWER SUPPLY
TB 1
BLACK
GREEN
RED
WHITE
METER
+15VDC
+5VDC
GND
ABORT SW
START SW
SW5
SW4
SW3
SW2
P4
P3
P2
P1
TIME/DETECT SW
AUTO/MAN SW
THRESHOLD POT
DIGITAL TIMER
AC
J10
J11
J9
PCM CONTROL BOARD
ORANGE PHOTOCELL
WHITE/ORANGE PHOTOCELL RETURN
BLUE/GREY
BLUE/WHITE
YELLOW
YELLOW/GREEN
ENGR
ECO#
REV
REVISIONS
BY
DATE
D.E.H.
970922A
A
ADD INDUCTORS TO RF GEN
D.E.H.
09/26/97
MARCH INSTRUMENTS INC.
SCALE: NONE
APPROVAL:
DATE: 03-10-97
DRAWN BY: B.C.
2-4 GAS PCM SYSTEM SCHEMATIC
PCM
F:\MARCH\ADWG-STD\9-SCHEM
MATERIAL:
REQ/ASSY
DRAWING # 9-154000
REV. A