TIME OF FLIGHT

Components from:

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INSTRUCTION MANUAL

RF POWER SUPPLY
D-1230 Rev 1

WARNING

THIS EQUIPMENT USES VOLTAGES WHICH
ARE DANGEROUS TO LIFE. IT SHOULD BE
SERVICED ONLY BY QUALIFIED PERSONNEL
USING PROPER SAFETY PRECAUTIONS.
DISCONNECT **ALL** CABLES BEFORE
REMOVING TOP COVER

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1.0 SPECIFICATIONS

1.1 MECHANICAL SPECIFICATION

Cabinet size	19" W. x 8.5" D. x 3.5" H.
Cabinet weight	6 Lbs.

1.2 ELECTRICAL SPECIFICATIONS

R.F. Output Voltage	0 to 2500 Volts p-p

1.3 SERVICE REQUIREMENTS

Input Power 85-265 Volts A.C.	1 PHASE, 50-60 Hz

2.0 GENERAL DESCRIPTION

Time of flight mass spectrometers have become widely used devices due to: (1) their ability to rapidly detect an entire mass spectrum on every pulse; (2) their ability to analyze and detect high mass; and (3) their potential for high sensitivity in trace analysis.

This has led to their use in experiments ranging from laser ionization and spectroscopy of small molecules and clusters to desorption of large proteins and other biomolecules.

However, a drawback of TOF devices is the lack of a means of storing ions prior to analysis. This inability to store ions compared to trap methods such as FTICR and ITMS place TOF at a disadvantage in terms of being able to manipulate ions for MS/MS or ion-molecule experiments, or for enhancing sensitivity through storage and integration of the signal. Thus a method of interfacing ion trap storage technology to time-of-flight might provide a hybrid instrument with some of the best properties of each individual device

A further limitation of the TOF in various situations is the resolution, which is determined by the initial spatial and energy distribution of the ions in the acceleration region of the TOF. Ions of the same mass must start at the same place with the same velocity in order to arrive at the detector at the same time. Thus, the ionization process has been usually restricted to a narrow space between the acceleration electrodes, thus affecting the ionization volume and consequently the sensitivity.

Resolution was also limited by the requirement that all ions have the same start time. Ions from a continuous external ion beam are thus difficult to introduce into the TOF with resulting time resolution. Ions can be injected axially to the flight path by beam deflection methods, where the ions are swept across a slit. This results in good resolution, but a poor duty cycle and thus poor sensitivity. Ions can be injected normal to the flight path, but this results in a limited mass window, and less than ideal resolution.

The QUADRUPOLE ION TRAP can be used to overcome these limitations. Ions can be created and stored during the time between extraction pulses. Since the extraction event is approximately 6 microseconds in duration it can be seen that duty cycle approaches 100% for storage times of over 1 millisecond.

In addition, ions which are extracted from the trap provide peaks with excellent resolution due to a small and well defined spacial and energy distribution. In the trap this appears to be independent of where or how they were created, but only depends on how long they have been stored in the trap. Ions created by an atmospheric pressure plasma source have been focused into the trap by an Einsel tube, accumulated and stored for up to 10 seconds in the trap. These ions were then ejected into the reTOFMS. The resulting peaks were less than 10 nanoseconds wide providing a resolution of well over 2000.

3.0 SYSTEM OPERATION

Ions can be created within the trap by laser excitation of residual species, intersection of laser with molecular beam, or by laser ablation of a sample probe. To accommodate these experiments, the ring electrode can be machined by cross drilling. Openings of 2.4mm (.094") have been used with no apparent degradation of trap performance. These openings can be made to cross in the geometric center of the trap, or slightly off center to be up-stream of the beam, or so that the new ions will be created outside the spot of maximum ion density.

Ions can be created external to the trap by any means available including ion beams of various sorts. These ions are then injected into the trap through the end cap opposite the TOF. If they are made near the trap, they can be focused and drifted toward the opening in the end cap by weak electrostatic fields. If they are generated farther away, they can be transported by Einsel tube or Brubaker (RF only) lens. Use of a quadrupole filter for this would allow the trap to be selectively charged. For this purpose, opposing end caps are normally furnished with a 3mm (.125") dia. aperture. For more sensitivity when the injected ion beam cannot be tightly focused, this opening can be enlarged and covered with a mesh.

Ions stored in the trap at ground potential are extracted from the trap and accelerated into the flight tube liner, which is at a uniform negative potential. The extraction pulse voltage can be provided by a pulser, which generates a simultaneous positive voltage on the entrance end cap and a negative voltage on the extraction end cap. Although this bipolar extraction is recommended, extraction can be accomplished by using either of the two voltages.

The trap mechanism is designed to operate either as an open structure to minimize ion-molecule collisions, or as a closed one for use with a buffer gas, etc. It can be readily changed from open to closed by adding two ceramic rings.

4.0 ION TRAP INSTALLATION

The trap structure is designed to replace the reflector plate and extraction grids of the ion source of all TOF instruments manufactured by R.M. Jordan Co. To install on one of these ion sources, the end caps and ring electrode are mounted on four .120" dia. Alumina sleeves, using .370" long spacers between end caps and ring electrode.

The trap assembly is thicker than the elements it replaces. The difference in thickness (.69") can usually be compensated for by changing the size or location of other components. R.M. Jordan Co. will be glad to assist you in modifying your present source in order to make the trap fit properly.

To mount in another way, such as to the face of a flange, drill and tap 4 #0-80 holes in a 1.50" square. Thread studs into the holes. Slide ceramic sleeves over the studs. Slide the trap elements onto the sleeves using the furnished spacers. Sleeves can be obtained from the manufacturer when needed for initial installation or replacement.
The acceleration grid should be located .125 inches from the outer face of the exit end cap.

5.0 DESCRIPTION OF CONTROLS

5.1 R.F. AMPLITUDE

Adjusts the amplitude of the R.F. voltage from 0-2500 volts p-p.

5.2 EXTERNAL RF AMPLITUDE CONTROL BNC CONNECTOR

A 0 to +9 volts input adjusts the RF amplitude from 0-2500 volts p-p. The RF amplitude linearly follows the input voltage.

5.3 INTERNAL/EXTERNAL RF AMPLITUDE CONTROL SWITCH

Switched left, the RF amplitude is controlled by the adjust knob. Switched right, the RF amplitude is controlled by an external D.C. voltage.

5.4 EXTRACTION DELAY ADJUST KNOB

Adjusts the delay between the R.F. turning off and the start of the extraction pulse. The adjustment is from 200nS before R.F. shut off to 4uS after.

5.5 EXTRACTION DURATION ADJUST KNOB

Controls the duration of extraction pulse between 1.5uS and 14uS

5.6 OVER CURRENT TRIP INDICATOR

Lights up to indicate an OVER CURRENT trip of the RF source.

5.7 RESET SWITCH

Push button switch used to reset the signal source on startup and after an OVER CURRENT trip event.

5.8 PEAK ADJUST SCREWDRIVER ADJUSTMENT

Adjusts the output frequency so that resonance can be accomplished between the RF SOURCE and the load. It is recommended that the RF source be peaked while INTERNAL/EXTERNAL control voltage is set to no greater than 90 percent of full scale (<9v). This allows for a narrow peak to be obtained while not tripping the OVER CURRENT circuit.

5.9 TRIGGER INPUT BNC

A TTL pulse on this line will trigger a crowbar (RF shutoff) event. NOTE: the external pulse generator must be capable of driving a 500 ohm load.

5.10 PULSER TRIGGER MONITOR BNC

This is a TTL pulse synchronized to the crowbar event. DURATION adjusts the pulse width of the PULSE TRIGGER MONITOR output signal. DELAY adjust knob controls the position of the PULSE TRIGGER MONITOR output signal relative to the crowbar event.

On the rising edge of a TTL signal (1 volt min.), the timing sequence will begin and the R.F. will turn off at the next zero voltage crossover. After the adjusted DELAY the extraction pulse will occur for the adjusted DURATION. After about 100 microseconds the R.F. will be back to its adjusted voltage.

5.11 EXTERNAL RF AMPLITUDE BNC

With the switch in the EXTERNAL position, a 0 to 10 volt signal will produce a corresponding level on the RF output.

6.0 DESCRIPTION OF REAR PANEL CONNECTORS

6.1 RF OUTPUT SHV CONNECTOR

This is the R.F. output for the Ring Electrode of the Ion Trap. This SHV should be connected to the ion trap using only the cable provided. This connection should be made before turning on the POWER. If a different cable is used the over current indicator will probably stay on due to a load mis-match.

6.2 RF SAMPLE BNC CONNECTOR

This is an AC decoupled view of the high voltage signal. Level of this signal is uncalibrated.

6.3 PULSE TRIGGER MONITOR SHV CONNECTOR

This is an alternate copy of the PULSE TRIGGER MONITOR on the front panel.

6.4 AC POWER INPUT

Accepts a standard EIA plug at 100 to 240 volts, 50-60 Hz

6.5 INTERNAL ADJUSTMENTS

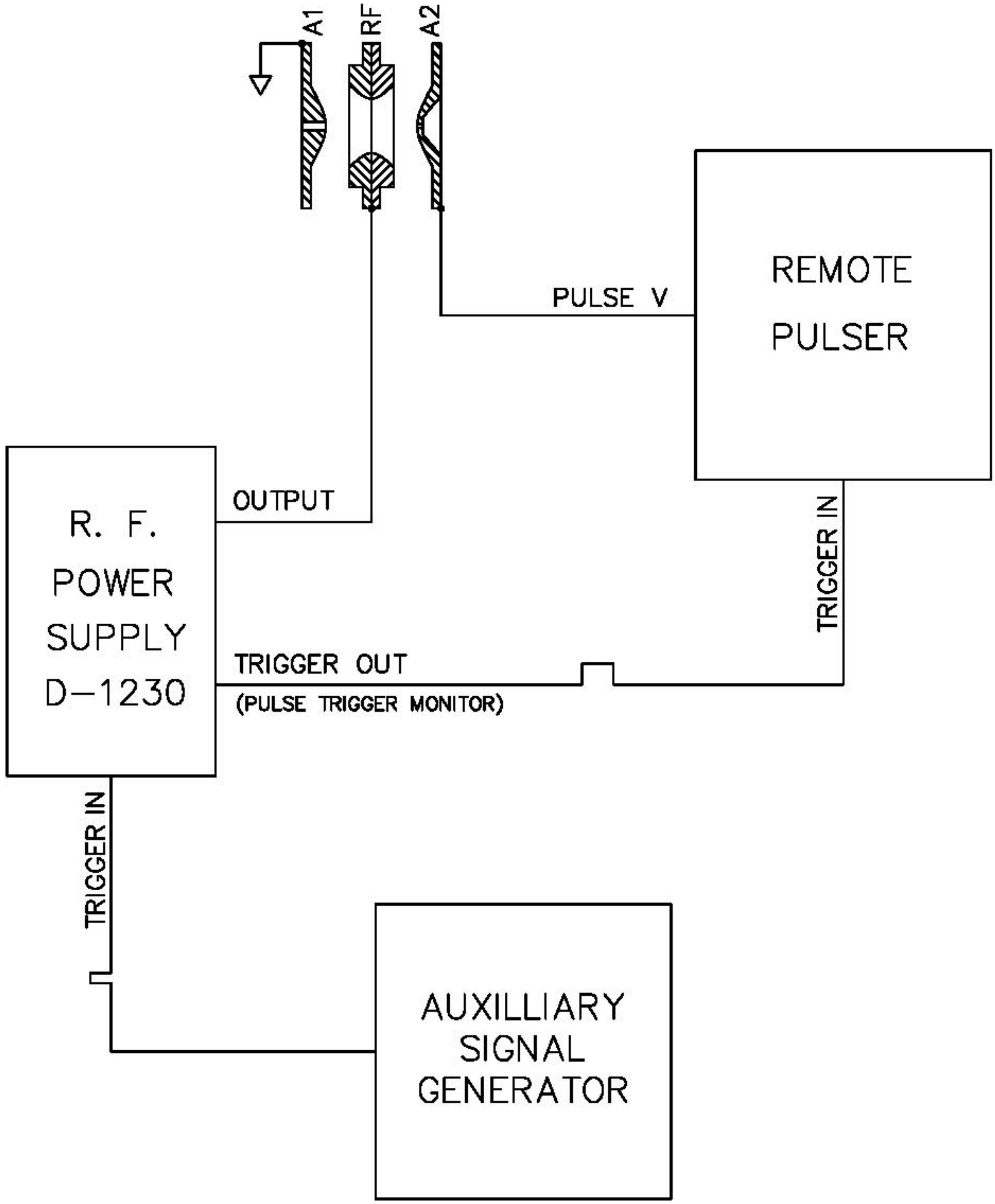
Crowbar slope is the two jumpers on the right (J3) of the Crowbar Board. It can be set for positive or negative slope by changing the orientation of the two jumpers. (NOTE: both jumpers must be installed at all times). The power supply is shipped with these jumpers in the positive position for use with positive ions. After the TTL, the RF will shut off when next the RF voltage crosses zero going in the positive direction. When working with negative ions is is sometimes an advantage to shut of the RF when it crosses zero going negative.

Crowbar activation point can be adjusted with R26. This will adjust the point on the RF waveform at which the crowbar fires. It is recommended that this be adjusted as close to the zero crossing as possible for minimal noise and disturbance to surrounding circuits. A zero crossing firing will produce a small over/undershoot on the RF signal.

7.0 CONNECTIONS

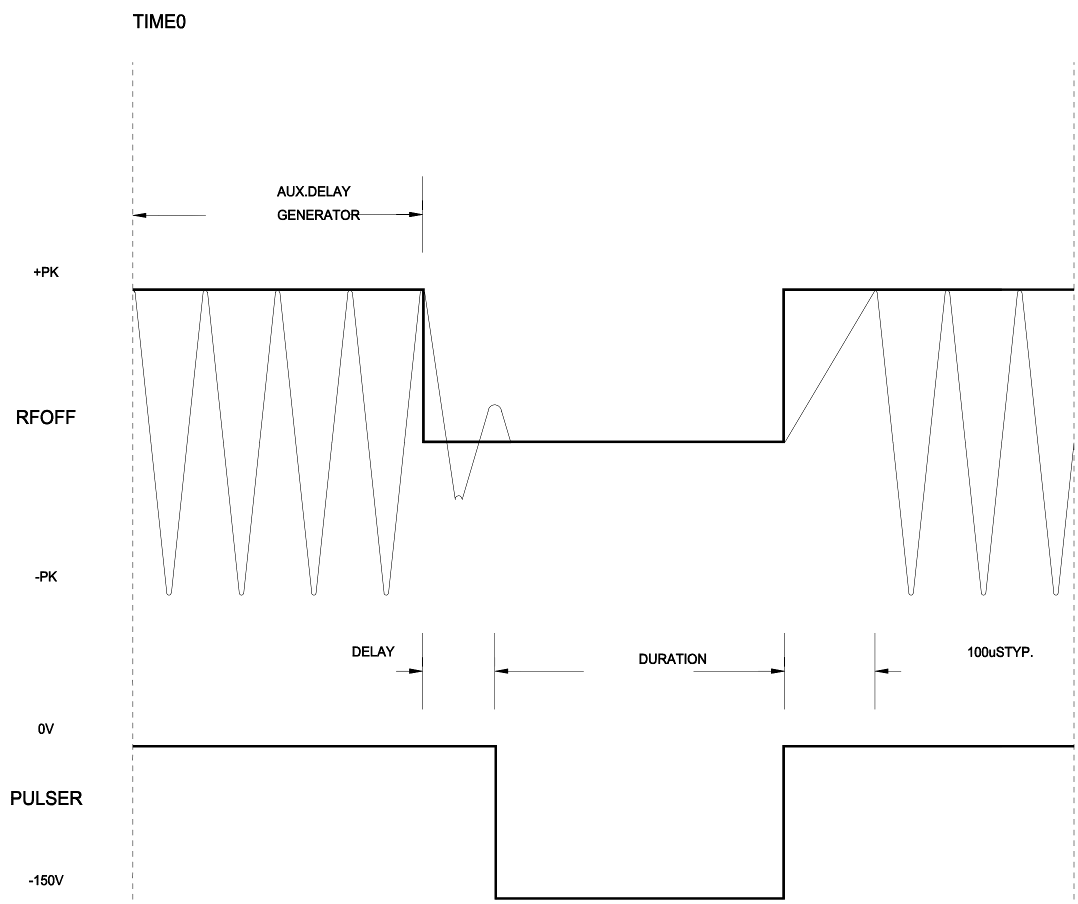
Using only the approximately 4' SHV cable supplied with the Ion Trap Power Supply, connect the "RF OUT" to the SHV Feedthrough which goes to the center ring of the Ion Trap.

Inlet End Cap A1 should be grounded and Extraction End Cap connected to Pulse Voltage.



ION TRAP CABLING

7.1 TIMING



AUX. DELAY + DELAY = TRAPPING TIME
DURATION = EXTRACTION TIME (2-5µS TYP.)
DELAY = SETTLING TIME FOR R.F. TURN OFF (.5-4µS TYP.)

The above timing diagram shows the typical timing delays needed for the operation of the Ion Trap. It is recommended that a Digital Delay Generator be used for controlling the interval that the R.F. is on from TIME 0. This time must be a very precise interval because it determines the Ion storage time. In some cases this can be in seconds. Use of a Digital Delay Generator can minimize timing jitter which will vary the storage time. If the storage time is not critical then a simple R/C timing delay can be used.

The initial time delay is from TIME 0 until the R.F. is triggered off. After a delay of about 2 to 3 microseconds to allow for the R.F. field to disappear, the end cap is dipped in voltage to extract the Ions from the Ion Trap. After a typical duration of 2 to 5 microseconds for Ion extraction, the end cap Pulser is turned off and the R.F. is turned back on. **It takes about 100 microsecond for the R.F. to come up to the adjusted voltage. The Ion Trap will continue to store Ions until the process is repeated.**

The Data System connected to the MCP output should be triggered from the rising edge of TRIGGER MONITOR CHANNEL 2 with the Data System Trigger Delay adjusted for the calculated flight time of the Ions from the Ion Trap.

8.0 OPERATION

The TOF can be operated in its standard mode leaving the extraction end cap voltage continuously on. In this condition, any ions created inside the trap by a laser pulse will arrive at the detector as more or less resolved peaks in the usual fashion. If ions are created outside of and focused into the trap, they will continue through the trap and appear as continuous noise on the detector.

Once it is established that there actually are ions, the R.F. voltage to the trap can be turned on and Pulser timing adjusted to operate in the storage mode.

9.0 OPERATION PRECAUTIONS

Make certain that system pressure is at least below 1X10-5 torr before turning on any voltages. A common failure is to assume that a lack of signal indicates a need for more sample (pressure). The power supplies, and especially the Pulser are vulnerable to even a brief arc-down.

Keep the operating voltages and pressure down until everything is running smoothly. The trap is by nature a sensitive device. If you cannot make enough ions at 1X10-6 torr, the fault is probably with ion generation or timing.

10.0 MAINTENANCE

10.1 CONTAMINATION

Most problems with the Ion Trap are due to contamination. The most troublesome contaminant can be easily avoided. This is Silicon pump fluid. Do not use Silicon pump fluid in instrument applications, especially where Microchannel Plates are used. Polyphenol Ether such as SANTOVAC V is known to be satisfactory. For very large pumps the cost may seem prohibitive. It is not likely to be as expensive as a shut down for instrument cleaning and replacement of Microchannel Plates.

Other common contaminants are recondensed hydrocarbons from fingerprints, etc. and other substances which are introduced as samples for analysis.

10.1.1 SYMPTOMS

Non conducting substances can condense onto electrode surfaces and form a dielectric coating which will surface charge and cause a distortion in the local field. Evidence of this is usually time dependent. Elements which have been tweaked for sensitivity must be readjusted. This is most noticeable with turn-on.

Conducting substances can coat insulators and create leakage paths between elements. This will cause various circuit elements to "talk to each other" and erratic meter readings or variations in the detected signal. Sensitivity can build up, then drop due to breakdown between elements.

As the Ion Trap gets dirty the amount of power that is needed for an adjusted RF amplitude will increase. This will continue until the power becomes so great that the OVER POWER will trip the power supply.

10.1.2 REMEDY

Ceramic parts can be cleaned by air abrasive cleaning followed by acid etching. After the parts are clean, they may be fired in air. Metal parts can be scrubbed with fine abrasive, then solvent and acid cleaned.

Grids can only be cleaned by washing in solvents and etchants, however this is seldom successful. It is usually better to replace them.

10.2 **OPERATING ENVIRONMENT**

Time between cleaning depends directly upon pressure and ion density.
When used in conjunction with a pulse nozzle or other source of a pressure burst, the elements of the Ion Trap can experience arc down due to a local pressure transient. This can be very hard to detect since it is synchronized with other events in the experiment. It is helpful to remember that Total Pressure Gauges only tell you the average pressure. Local pressure can be momentarily much higher. If there is a possibility of this, it can be tested by changing the carrier gas to one which is more stable (less easily ionized) and taking note of any difference.

Many fail to note that cold traps must be valved off from the experiment before they are allowed to warm up. A clean experiment at the end of a working day can be a contaminated experiment the following day due to recondensation from the cold trap.

10.3 VISUAL INSPECTION

Contaminated metal parts can cause performance problems while appearing to be clean and shiny.

Discoloration of ceramic components indicates a need for cleaning. The discoloration should be removed as in 9.1. Although standard ceramic cleaning solutions can be used, be sure to mechanically remove any visible discolorations before using chemicals.

Ceramic sleeves should be inspected for drag marks which are caused by sliding off the metal parts of the trap for cleaning or inspection. These can cause leakage between elements of the trap. This should be suspected when the R.F. voltage seems to sag.