RC-44 RAMP GENERATOR
INSTRUCTION MANUAL

Instruction Manual (Rev. C)
51504-M-00

burleigh

Burleigh Instruments, Inc.
Burleigh Park
P.O. Box E
Fishers, NY 14453-0755
Tel. (716) 924-9355
Fax. (716) 924-9072

TABLE OF CONTENTS

1. INCOMING INSPECTION

1.1. Visual

Burleigh Ramp Generators have been packaged in a special carton designed to give maximum protection during shipment. If the outside of the shipping carton is damaged, notify your shipping department immediately. The shipping department may wish to notify the carrier at this point.

If the shipping carton is undamaged externally, the instrument should be removed from the carton. If any damage is evident visually or if any rattling can be heard when the unit is shaken lightly, notify Burleigh Instruments and your shipping department. It is advisable to save the special carton for future storage or transportation.

1.2. Electrical

Assuming that the instrument is in good condition visually, a preliminary check of its electrical operation should be made. This can be accomplished as follows: plug the instrument into the appropriate outlet as indicated on the rear panel, connect the OUTPUT ÷ 100 connector on the rear panel to an oscilloscope, set the RAMP DURATION to 100 ms, set the RAMP AMPLITUDE to midposition and set the RAMP BIAS knob midway (the amplitude and bias controls are 3-3/4 turn slip clutch potentiometers). An unclipped, 5 V, repetitive ramp should be observed. Should the RC-44 fail this initial check, Burleigh Instruments should be notified.

1.3. Quality Control

All Ramp Generators undergo several stages of inspection, test, and calibration before shipment, including a burn-in at elevated temperatures. The instrument has also undergone an exhaustive final test and calibration process prior to shipment. Should a problem arise during the warranty period, Burleigh's policy is to repair any instrument within one week of receipt at the factory. During this time, the instrument will be burned-in for an additional period of 3 days, before rechecking and returning to the customer.

2. DESCRIPTION

The RC-44 Ramp Generator is designed to drive Burleigh Fabry-Perot Interferometers, Tunable Etalons, PZT Aligner/Translators, elements of a laser cavity or any instrument which uses three independent piezoelectric elements. The Ramp Generator controls these elements to provide two basic functions: scanning and alignment. Two separate and independent circuits are used to achieve these results. See Figure 1.

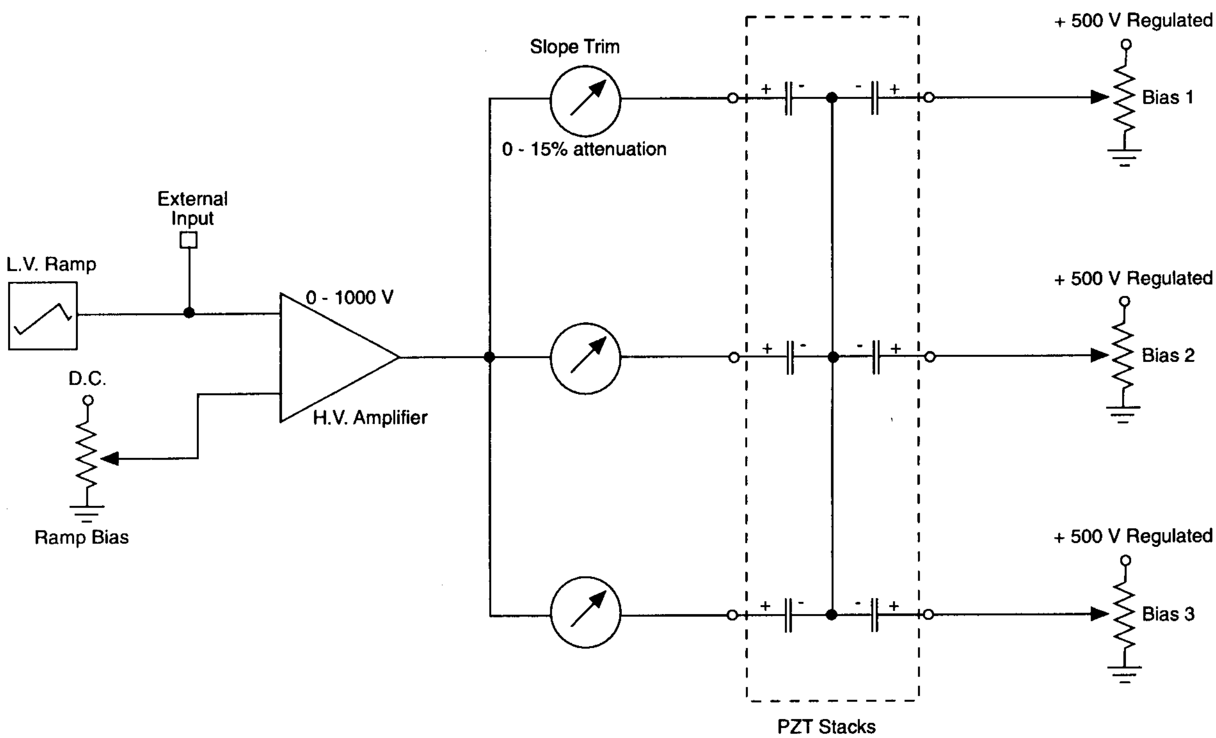

Figure 1. Ramp Generator Circuitry

2.1. Ramp Section

Consult Figure 2 throughout the following section. The ramp circuitry of the RC-44 provides a linear ramp waveform with an amplitude variable from 1 to 1000 V and a ramp duration variable from 20 ms to 16 minutes. These are controlled by knobs labeled RAMP AMPLITUDE and RAMP DURATION (in conjunction with the X1 → X100 MAGNIFIER).

In addition to the linear ramp, the programmable ramp feature provides an adjustable first order correction which is added to the low voltage ramp before being fed into the high voltage DC amplifier. This feature adds a curvature to the ramp and corrects for non-linearities in the PZT material. The result is a highly linear scan.

The high voltage ramp is further processed by the slope trim circuitry. This unique feature permits a 0-15% independent adjustment of the ramp slope to each piezoelectric element. Using the three TRIM controls, it is possible to compensate for different sensitivities in the three PZT elements. This feature permits tilt-free scanning to be achieved in any three-element PZT drive, even if the PZT elements are not perfectly matched.

The output of the ramp section is carried by three separate pins on the Viking multi-pin rear panel OUTPUT connector. These three leads are applied to the positively poled side of each of the three PZT elements in the device being driven.

The RAMP BIAS control carries the DC level of the ramp from 0 to 1000 V, allowing linear tuning of the device being driven. In a scanning Fabry-Perot, for instance, the RAMP BIAS knob is often used to position the beginning of one Free Spectral Range with respect to the beginning of the ramp or some other reference position.

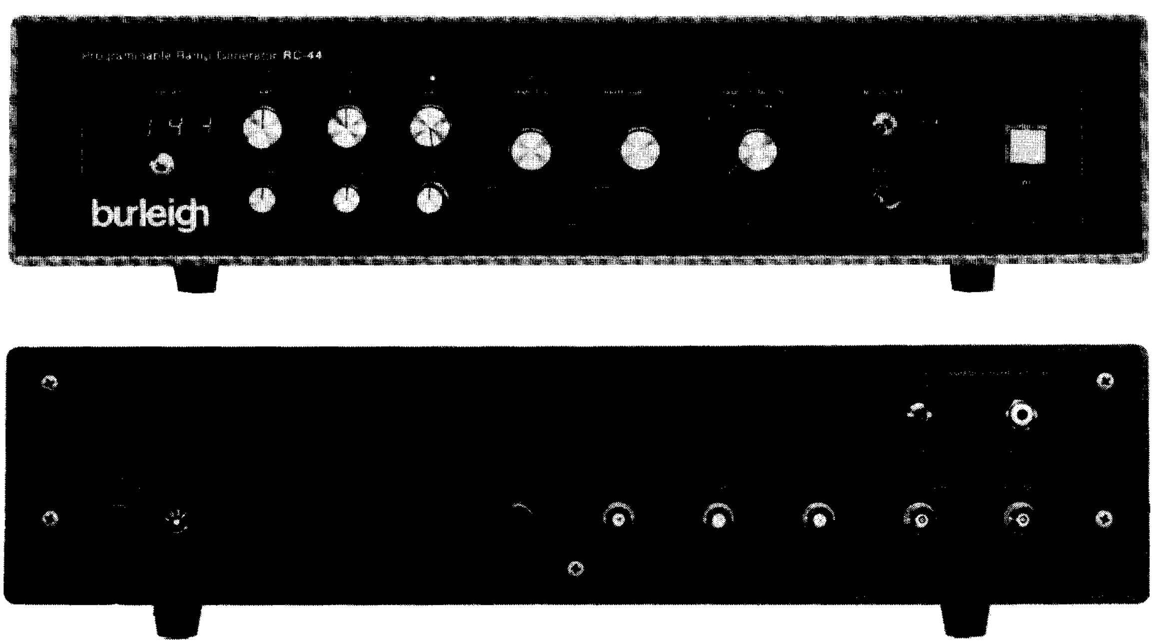

Figure 2. Front and Rear Panels

2.2. Bias Section

Three controls labeled BIAS 1, BIAS 2, and BIAS 3 adjust the DC voltage to each of three independent PZT elements. When connected to a Fabry-Perot stack assembly, these signals are applied to the positive side of the PZT bias stack, the negative side is returned to ground. (NOTE: PZT ramp and PZT bias stacks are electrically separate). With other piezoelectric devices that use single PZT elements, the bias voltages may be applied to the negative side of each PZT element with the ramp voltage on the positive side.

2.3. Control Signals

The connections for these signals are present on the rear panel to simplify operation.

1) Output ÷ 100 BNC connector

   The ramp output, attenuated by a factor of 100, allows display of the ramp waveform on any oscilloscope, chart recorder, or other display system without the concern of handling a 1000 V signal and can be used to slave other units.

2) Trigger BNC connector

   Triggering a scope or other instrument in a display system is simplified by use of a square wave pulse of +12 V which occurs for the duration of the ramp retrace.

3) Blanking BNC connector

   A blanking signal of -12 V is turned on for the duration of the retrace time so that the display system can be blanked off during the flyback of the PZT element.

2.4. External Programming

Two rear panel external inputs can be used to program the RC-44 in specialized applications. With the EXTERNAL INPUT connector, the high voltage DC amplifier can be driven by an error signal in a feedback loop or by a waveform other than a ramp. To do this, set the ramp duration to off. (If the ramp duration is not turned off, the external input will be summed with the ramp.) The gain of the amplifier is variable from 0 to +100 using the front panel amplitude control.

A second, low gain input to the amplifier is labeled DRIFT CONTROL. A low level DC signal derived from a temperature recording device or from a stabilization system can be fed into the DRIFT CONTROL input to compensate for axial drift in the cavity being controlled. The proper error signal level is determined experimentally.

2.5. Digital Voltmeter Section (DVM)

The RC-44 contains a 3 1/2 digit voltmeter for measuring the voltages present on the three bias controls as well as the ramp voltage. Selection of the voltage measurement of interest is accomplished by pressing the display button, to light the LED indicator over the desired control knob.

2.6. Programmable Ramp

This is controlled by an on/off switch and adjustment potentiometer on the rear panel. The amount of correction to the ramp drive is adjusted here.

3. OPERATION

CAUTION: The RC-44 Ramp Generator is a low impedance source and is capable of generating voltage levels in excess of 1000 V. Do not attempt to make any connections to the Ramp Generator when the unit is turned on. After turning the RC-44 off, it is good practice to wait for a short time until any residual voltage on the capacitive filtering circuits have been discharged.

3.1. Initial Check

Check to see that the Ramp Generator is operating properly before connecting it to the piezoelectric device. To do this, connect the OUTPUT ÷ 100 signal to an oscilloscope and connect the TRIGGER output to the external trigger on the scope. Set the RAMP AMPLITUDE control to about mid-position, or about two turns from fully counter clockwise. Set the RAMP BIAS control to about 1 turn from fully counter clockwise and set the RAMP DURATION to 50ms. For this test, the position of the BIAS controls is not important. The scope should be dc coupled.

Turn the Ramp Generator on. You should observe a ramp with its base line at about 2 V and a peak-to-peak amplitude of approximately 500 V. Note that the ramp is positive going. The base line can be raised or lowered with the RAMP BIAS control.

The ramp duration should be approximately 50ms and the retrace duration approximately 10 ms. Note that the beginning and end of the ramp waveform are slightly rounded. This is programmed into the Ramp Generator to reduce accelerations in an optical element being translated by the PZT. Without this rounding, an undesirable mechanical ringing can be set up in the piezoelectric device. On longer ramp times, this rounding is a negligible fraction of the ramp duration.

Now, check the operation of the ramp for longer ramp durations. Set the RAMP DURATION to several seconds and press the RESET button. The ramp should return to its starting point. You will note that further reducing the RAMP BIAS control causes the amplifier to clip. Increase the RAMP AMPLITUDE so that the peak-to-peak voltage is at least 1000 V corresponding to a ramp amplitude of 1000 V. (At the 20ms setting, the maximum amplitude may be slightly less than 1000 V). The RAMP AMPLITUDE and RAMP BIAS controls should be set such that there is no clipping at the bottom or top of the ramp.

3.2. Operational Check

Now the Ramp Generator can be connected to the piezoelectric device being driven. Connection to Burleigh's Fabry-Perot Interferometers is made by a cable supplied by Burleigh. Turn off the Ramp Generator and connect one end of the cable to the Ramp Generator and the other to the device, if it is not already attached.

Now set the RAMP BIAS control to about one turn and set the RAMP AMPLITUDE control to approximately one turn. Set the RAMP DURATION to 50 ms and turn the RC-44 on. Usually a very faint clicking sound will be heard from the piezoelectric elements. This is normal and indicates that the RC-44 is functioning properly. (A sharp clicking indicates that the ramp is being clipped, or possibly that the piezoelectric device is arcing). If the Fabry-Perot has been aligned, the detector positioned and the Fabry-Perot is being excited by an external source, some output pattern should be observed from the detector.

Now use the individual BIAS controls to optimize the alignment of the Fabry-Perot. By adjusting the RAMP BIAS knob, the position of one free spectral range can be varied with respect to the beginning of the ramp. Now adjust the RAMP BIAS control to bring the ramp baseline to near 0 V and the RAMP AMPLITUDE control to near maximum. At this point, the output of the RC-44 should be approximately 1000 V peak-to-peak.

3.3. Trim Controls

In a Fabry-Perot Interferometer, if the three piezoelectric elements have slightly different sensitivities, tilt during scanning will result. The amplitude of the pattern transmitted in each free spectral range as the Fabry-Perot scans through several free spectral ranges will change, indicating less than optimum alignment for some portion the scan.

If you observe this effect, the TRIM controls can be used to compensate for the different sensitivities of the piezoelectric elements. It is very convenient to use the three BIAS controls to determine the relative sensitivity of the stacks before making this adjustment.

To do this, turn all three TRIM controls fully counterclockwise. Set the RAMP AMPLITUDE such that at least five orders of the Fabry-Perot can be displayed on an oscilloscope. Make sure the collimated input to the Fabry-Perot is expanded to cover the full aperture. Now use the BIAS controls to optimize the peak height and the finesse of all five peaks.

After this adjustment, you will find the peaks will be of unequal heights. Adjust the BIAS controls to cause the central peak to be the highest. While observing the peaks, rotate BIAS 1 clockwise and counterclockwise about 1/2 to 3/4 of a turn. As you do this the highest peak will shift to the right or left of center. Note this direction of shift.

For an RC Series Fabry-Perot: If while rotating the BIAS knob clockwise, the highest peak appears to go to the right, the peaks are said to be "following" the BIAS adjustment. If the peak appears to go to the left of center, then that channel is not following the BIAS and will need TRIM.

For a TL Series Fabry-Perot: If while rotating the BIAS knob clockwise, the highest peak appears to go to the left, the peaks are said to be "following" the BIAS adjustment. If the peak appears to go to the right of center, then that channel is not following the BIAS and will need TRIM.

NOTE: **One TRIM control should always be fully counterclockwise and the other two will be set with respect to the third. Any problems in obtaining this final position should be reported to the factory.**

Repeat the above procedure for all three BIAS controls. Be sure to center the highest peak and turn all three TRIM controls fully counterclockwise at the beginning of the test. Note which channels do not "follow" the BIAS and hence need TRIM. It will be found that a maximum of two BIAS channels will need TRIM, never all three. Two channels are always reference to a third. The remainder of these instructions assume that two channels need TRIM.

After it is determined which two channels require TRIM, re-optimize all BIAS controls such that the central peak is the highest. (NOTE: to this point, all TRIM controls should remain fully counterclockwise). Starting with the first channel requiring TRIM, increase its TRIM control (clockwise) until all the peaks drop down to approximately the same peak height. Again, re-optimize the peak height and finesse of the peaks by adjusting the three BIAS controls only. Repeat this procedure between the two channels until after re-optimization, all peaks are of the same height and of the same width.

This procedure is completed when all peak heights increase or decrease together without shifting position as one rotates any of the BIAS controls. At this point, the TRIM control settings should be noted as they should not need further adjustment with this particular Fabry-Perot.

3.4. Programmable Ramp

The programmable ramp allows the addition of a quadratic correction to the ramp to compensate for non-linearity in the piezoelectrics. The PROGRAMMABLE RAMP ON/OFF switch enables the programming feature. The PROGRAMMABLE RAMP ADJUST sets the amount of curvature programmed into the ramp. This must be adjusted to linearize the motion of the particular PZT device being driven.

To adjust the Programmable Ramp, observe the interferometer spectrum of a light source with one or more narrow spectral lines (e.g. HeNe laser light) on an oscilloscope with a good linear time base. Set the RAMP AMPLITUDE near maximum so that many orders of the spectrum are swept.

Switch ON the PROGRAMMABLE RAMP, magnify the oscilloscope trace and compare the width of a free spectral range near the beginning of the ramp to one near the end. Set the PROGRAMMABLE RAMP ADJUST potentiometer so that the free spectral range observed on the oscilloscope has the same width near both ends of the ramp. The actual ramp output can be conveniently observed on the RAMP OUTPUT ÷ 100.

For higher motion linearity over a restricted portion of the ramp, repeat the above procedure with the RAMP AMPLITUDE and RAMP BIAS set to cover that range.

Figure 3 shows an uncorrected ramp. Figure 4 shows the same ramp with quadratic correction which, when used to drive a non-linear PZT, results in a linear scan. Typical interorder PZT scan linearity is on the order of 0.1% to 0.5%.

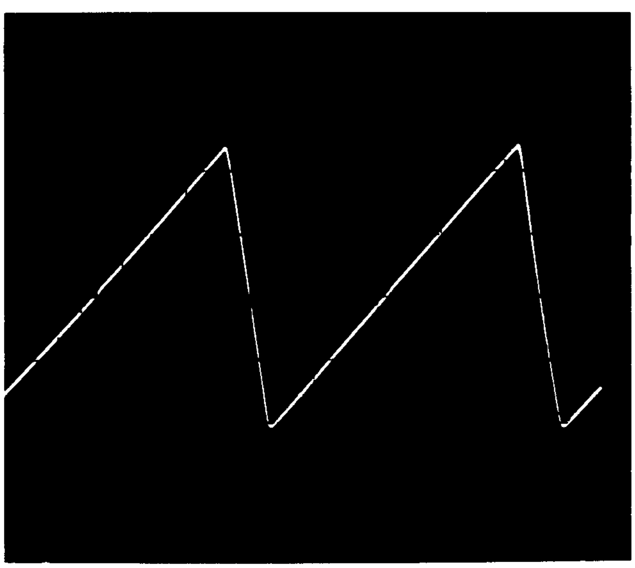

Figure 3. Ramp Waveform without correction. 1000 V amplitude, 100 msec duration.

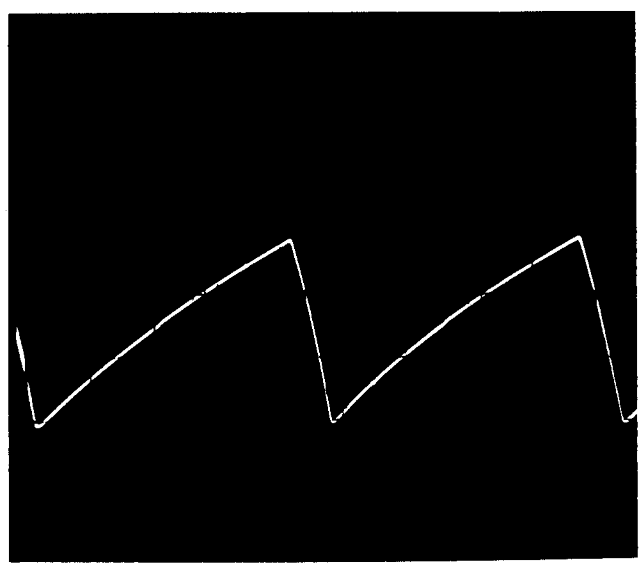

Figure 4. Ramp Waveform with programmed correction. 750 V amplitude, 100 msec duration.

4. PERFORMANCE

The major performance characteristics of the high voltage DC op amp in the RC-44 are depicted by the following sets of operational data. (See Figures 5-10). It should be noted that the RC-44 high voltage DC op amp, like all DC amplifiers, is somewhat non-ideal in certain operating characteristics and it is hoped that a careful examination of the following data will enable the user to optimize the operation in their system.

These data show gain versus frequency for different operating conditions. Burleigh's PZT devices have input capacitances of 5 nf to 50 nf, and typically are driven with 200 V to 1000 V.

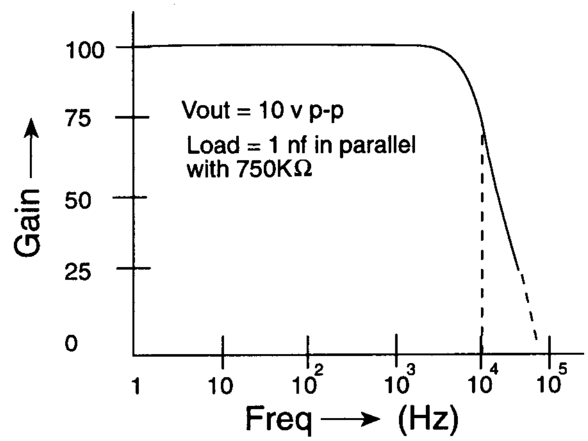

Figure 5. HV dc op amp small signal response

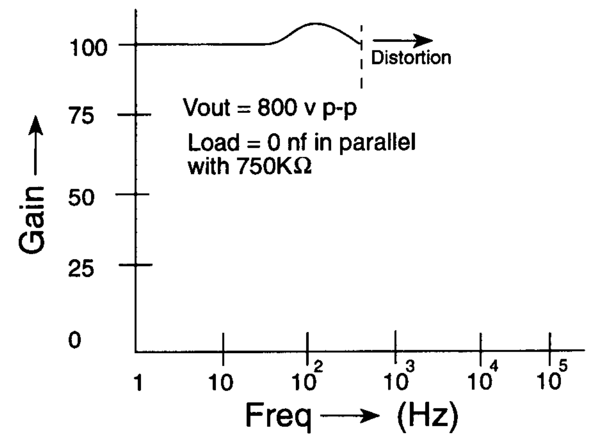

Figure 6. HV dc op amp large signal response

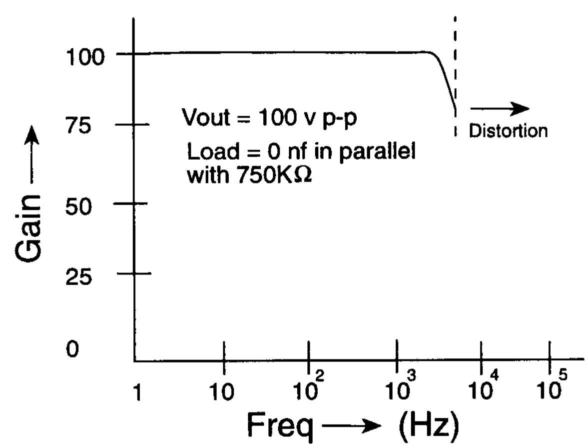

Figure 7. HV dc op amp response for 0 nf load

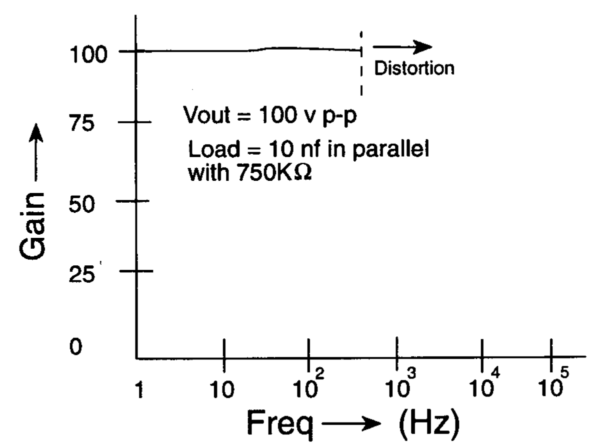

Figure 8. HV dc op amp response for 10 nf load

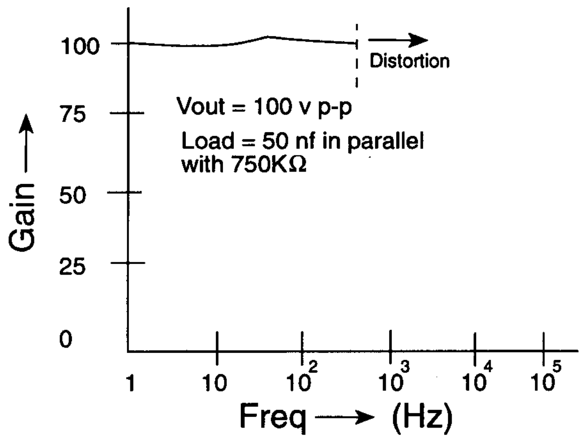

Figure 9. HV dc op amp response for 50 nf load

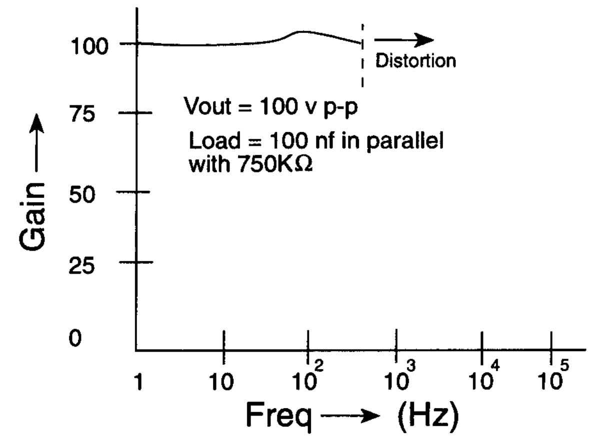

Figure 10. HV dc op amp response for 100 nf load

Ramp linearity is one of the more important specifications in the RC-44. Data recording in Fabry-Perot interferometry requires a linear base line unless sophisticated electronics are available and can be driven off the Ramp Generator. Figure 11 shows ramp linearity for a 500 ms ramp rate. The measured integral linearity is less than 0.5% between the 10% and 90% points. The rounding observed is programmed into the RC-44 to prevent mechanical ringing of the optic being driven on retrace.

Figure 11. 0 to 1000 V ramp, 500 ms duration, integral linearity ≤½% from 10% to 90% points

Noise characteristics of the RC-44 Ramp Generator are also important. Low signal recording of data requires not only a stable optical system, as in Fabry-Perot interferometry, but also a low noise electronic driver. The RC-44 has extremely low noise and ripple, less than 30 mv RMS (70 mv p-p) typical as shown in Figure 12.

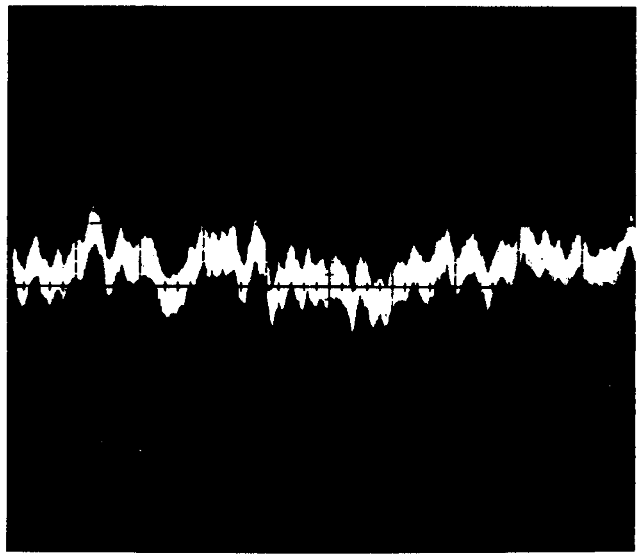

Figure 12. Noise and ripple on 16 minute ramp measured at 500 V, 40 mV p-p

5. SERVICING

Servicing should be carried out only by skilled personnel who are thoroughly familiar with modern semiconductor circuitry. The integrated circuits used in this unit are especially delicate and may be destroyed by misapplication of test voltages. One is advised to study the pertinent circuit diagrams until sure of how the unit performs before probing the circuit with test instruments. Most of the circuitry used here is relatively straightforward and its internal operation should be self-explanatory.

5.1. Low Voltage Ramp Generator

The low voltage ramp is generated by Z5 (the waveform generator chip). R96 adjusts only the ramp retrace time while R15 adjusts the total ramp time. FET Q6 discharges the timing capacitors when the reset push button is depressed. Z5 also provides square wave output which is split and buffered to provide trigger and blanking output.

Signals from the low voltage ramp and external input are summed at amplifier Z2C and subtracted from the quadratic correction generated when the programmable feature is used. This amplifier has a 100 K potentiometer in its feedback loop and will adjust the amplitude of the signal being fed to the high voltage driver Z2B. This drives Q1 (BU209), giving the final high voltage output. The bias level of the output is adjusted at this amplifier by R36 on the front panel.

The drift amplifier Z2D is a fixed gain amp that can be configured as single input or differential input with removal of a jumper for reduction of ground loop noise. This output is summed with the ramp or external signal.

A precision resistive divider along with buffer Z2 provides a high accuracy divide by 100 signal. This divided output signal is fed back to Z13 where it is arithmetically squared, inverted, buffered and sent to Z2C to be differenced with the ramp signal and provides a quadratic correction to the ramp output waveform.

Power supplies are generated from 110 vac (or 220 vac) via a custom transformer. All supplies are DC, the low voltage supply being regulated by I.C. voltage regulators which are output and temperature protected. The high voltage is regulated via a floating series pass regulator comprised of Z15 and Q2 (2SD627) and regulators at about 1200 volts DC This is supplied to the trim controls which return to the ramp output. The bias controls use the same regulator with the output voltage divided by R62 (430K 2W).

5.2. RC-44 Digital Voltmeter Section

The three high voltage bias outputs and the ramp ÷ 100 output are divided down with precision divider networks to provide a maximum 1 V signal to the DVM circuitry. These signals are input to Z17 (CD4066) which electronically selects the signal to be measured via the display pushbutton. The analog to digital conversion is done by Z20 and is displayed on four seven segment LED's. The signal being measured is indicated by LED illumination above the control for that signal.

5.3. Troubleshooting

The RC-44 Ramp Generators are designed for ease of troubleshooting and repair. Critical components are mounted in sockets for easy checking or replacement. Test points are provided to monitor every important function of the instrument. The following is a troubleshooting guide.

CAUTION: This instrument has a high voltage supply that is DANGEROUS. Disconnect the AC power and wait two minutes before removing or replacing any components.

NOTE: To prevent destruction of digital voltmeters when attempting to read high voltage supplies, the following procedure is recommended: for raw high voltage, measure directly across C1 and then directly across C2. Readings should be approximately +750v each (»10v ripple), then simply add the values. It is suggested that the regulated high voltage be measured with an oscilloscope (or DVM rated to read a maximum of 1500 VDC, such as Beckman series H3010).

1) Power supply check

Test point 3	-12 VDC
Test point 4	+12 VDC
Test point 6	+5 VDC
Test point 1	+750 VDC
Test point 2	regulated high voltage (+1200 VDC)

2) If all power supplies are functioning, check test point 5 (low voltage ramp). A ramp amplitude of ±4 volts should be present. If not, replace Z5 (ICL8038CCPD).

3) If the ramp does not reset with the reset button, replace Q6 (2N5460).

4) If the H.V. supply does not regulate (i.e. R56 single turn pot has no effect on test point 2 voltage), replace Z15 (741). If still inoperative, check D7 and D8 (1N4744 15v Zener diodes) and D9 (1N4751 30v Zener diode), replace as needed. Also replace Q3 (2N6308) if D7, D8 or D9 is replaced.

5) If the programmed ramp feature malfunctions, replace Z13 (ICL8013CCTZ) and Z3 (LM348).

6) If no high voltage ramp is present, replace Z2 (LM348). If it still malfunctions, replace Q1 TFK (BU209).

7) If a ramp voltage is present but clips the waveform at or below 1000v, this is indicative of a low A.C. line voltage. Readjust R56 for a fully unclipped ramp waveform.

8) a) Display does not light up: Replace DS75492 on display board. If still inoperative, replace Z20 (ADD3501CCN).

   b) Illuminated display, but no reading: Momentarily turn power off and then on.

   c) Bias LEDs do not light or are malfunctioning: Replace Z18 (74C902N) and Z16 (CD 4022BCN).

NOTE: **This instrument uses a "1/2 A Slo Blo" fuse on the back panel. Do not substitute any other type. Troubleshoot the problem and inform Burleigh Instruments, Inc.**

5.4. Converting from 110 VAC to 220 VAC

To convert instrument from 110 VAC to 220 VAC, remove top cover, locate switch 1 (near transformer), slide to voltage indicated by arrow, replace 1/2 amp S.B. fuse with 1/4 amp S.B. fuse. Replace cover.

6. SPECIFICATIONS

Ramp Section

Amplitude	3-3/4 turn potentiometer (slip clutch)
Duration	9 position rotary switch and toggle switch. 20, 50, 100, 200, 500 ms, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000 sec.
Bias	3-3/4 turn potentiometer (slip clutch)
Output voltage	+3 V to 1000 V max, variable 2 ma max.
Output current	2 ma max.
Slew rate	1 V/µsec max.
Input	10 V for 1000 V out at max. gain
Bias	+3 to 1000 V
Noise and Ripple	30 mv RMS max.
Long term stability	≤ 300 mv DC typical (24 hours)
Regulation	± .05% for line voltage 108-128 VAC. Can be adjusted for 95-115 VAC. Consult factory.

Ramp linearity without correction and 90% points.
≤ 0.25% integral linearity between 10%

PZT linearity with correction and 90% points :

*Visible PZT material	Interorder linearity for a .6328 µm source: < 0.1% with 1.25 µm scan between 10%
*Infared PZT material	Interorder linearity for a .6328 µm source: ≤ 0.5% with 7 µm scan between 10%

External input gain	+100
Slope trim	0-15% attenuation of ramp slope

Bias Section

Controls	Three 3-3/4 turn slip clutch potentiometers
Bias voltage	0 to 500 VDC
Output current	0.1 ma max.
Noise and ripple	20 mv RMS max.

Connectors

External input	Insulated BNC
Drift control input	Insulated BNC
Output ÷ 100	BNC
Trigger output	BNC
Blanking output	BNC
High voltage output	Viking thorkom TKR-07

Wiring for HV output:

Pin 1 - H.V. ramp for element 1 - red
Pin 2 - Bias voltage for element 1 - orange
Pin 3 - H.V. ramp for element 2 - black
Pin 4 - Bias voltage for element 2 - white
Pin 5 - H.V. ramp for element 3 - blue
Pin 6 - Bias voltage for element 3 - green
Pin 7 - Ground - white/black & shield

Wiring for I/O Output 7-pin Winchester connector

A Timing resistor - red
B Timing resistor - orange
C +12 V DC - black
D -12 V DC - white
E Voltage comparator input Z3A - blue
F Voltage comparator input Z3B - green

Weight	15 lbs.
Dimensions	4" x 17" x 12"
Line Cord	6' with standard American UL 3 prong plug

7. WARRANTY

The Burleigh RC-44 is warranted against defects in material and workmanship for a period of one year after date of delivery. During the warranty period, Burleigh will repair or at its option, replace parts which prove to be defective when the instrument is returned prepaid to Burleigh Instruments, Inc. The warranty will not apply if the instrument has been damaged by accident, misuse, or as a result of modification by persons other than Burleigh personnel.

NOTE: **You must call Burleigh or your representative for a Return Authorization Number (RA#) before returning any product. This will insure the prompt handling of the repair.**

The liability of Burleigh (except as to title) arising out of supplying of said product, or its use, whether under the foregoing warranty, a claim of negligence, or otherwise, shall not in any case exceed the cost of correcting defects in the product as herein provided. Upon expiration of the warranty period specified herein, all liability shall terminate. The foregoing shall constitute the sole remedy of the buyer. In no event shall the seller be liable for consequential or special damages.

burleigh

Burleigh Instruments, Inc,
Burleigh Park
P.O. Box E
Fishers, NY 14453-0755
Tel. (716) 924-9355
Fax. (716) 924-9072

RC 333 10-93
51504-0