RC-45 CFT CONTROLLER
TECH MEMO/INSTRUCTION MANUAL

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1. INCOMING INSPECTION

A. Visual

Burleigh RC-45 CFT Controllers 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.

B. 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 a 120 VAC or 220 VAC 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. With nothing plugged into the rear panel Temperature Control socket, the UNDER DEVIATION LED should light up. Should the CFT Controller fail this initial check, please consult Burleigh Instruments, Inc.

C. Quality Control

All CFT Controllers undergo several stages of inspection, test and calibration before shipment, including a burn-in at elevated temperatures for 7 days, minimum. The instrument has undergone an exhaustive final test and calibration process prior to shipment. Should a problem arise during the warranty period, contact Burleigh's service department.

2. DESCRIPTION

The CFT Controller is designed to drive the Burleigh Confocal Etalons, PZT Translators or any other single or multi-element piezoelectric drive in which alignment is not critical. Incorporated with the scanning electronics is a temperature controller and photodetector amplifier.

Refer to Figure 1 throughout the following descriptions.

A. Ramp Section

The ramp circuitry of the RC-45 provides a linear ramp waveform with an amplitude variable from 0 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 toggle switch, located to the right of the RAMP DURATION). 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 output is carried to a BNC connector on the rear panel.

The RAMP BIAS control varies the DC level of the ramp from 0 to 1000 V, allowing linear tuning of the device being driven. In a scanning etalon, for instance, the RAMP BIAS knob is often used to position the beginning of the ramp or some other reference position.

B. Temperature Control

The RC-45 contains an active DC-proportional temperature controller to thermally stabilize the CFT unit against external temperature variations. Both LEDs are off when the temperature set point has been reached. The control temperature is selected by a switch, the LOW setting (approximately 30°C) is preferable if normal ambient conditions exist. The HIGH setting (approximately 33°C) should be used when the ambient is higher than normal. The set points can be changed; consult the factory.

C. Photodetector Amplifier

An amplifier with adjustable gain and bias controls is provided for use with either visible or infrared detectors. When the photodetector amplifier output is connected to an oscilloscope or chart recorder, the magnitude of the output can be set via the gain control. The DC offset of the signal can be adjusted by means of the bias control.

D. Control Signals (Rear Panel)

These signals are present on the rear panel to simplify operation.

1) HV Output

This is the high voltage output from the ramp generator. Connect it to the PZT elements in the CFT etalon.

2) 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.

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 during the flyback of the PZT element.

4) Trigger BNC connector

Triggering an oscilloscope is simplified by use of a square wave pulse of +12 V which occurs for the duration of the ramp retrace.

E. External Programming (Rear Panel)

Two rear panel external inputs can be used to program the RC-45 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 on the front panel 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 unit such as the Burleigh DAS-10 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.

F. Temperature Control Connector

This is a 4 pin Winchester connector. The CFT temperature sensor and heating element are connected via this port.

G. Photodetector Input/Output

The photodetector signal is introduced via a 5 pin Winchester connector. The amplified voltage output for an oscilloscope or chart recorder is provided on the BNC Connector.

H. I/O Port

This is a 7 pin Winchester connector. The ramp segmentation feature is accessed from this port and typical connections are shown in the schematics.

I. Programmed Ramp

This is controlled by an ON/OFF switch and adjustment potentiometer. The amount of curvature added to the ramp voltage is adjusted with these controls.

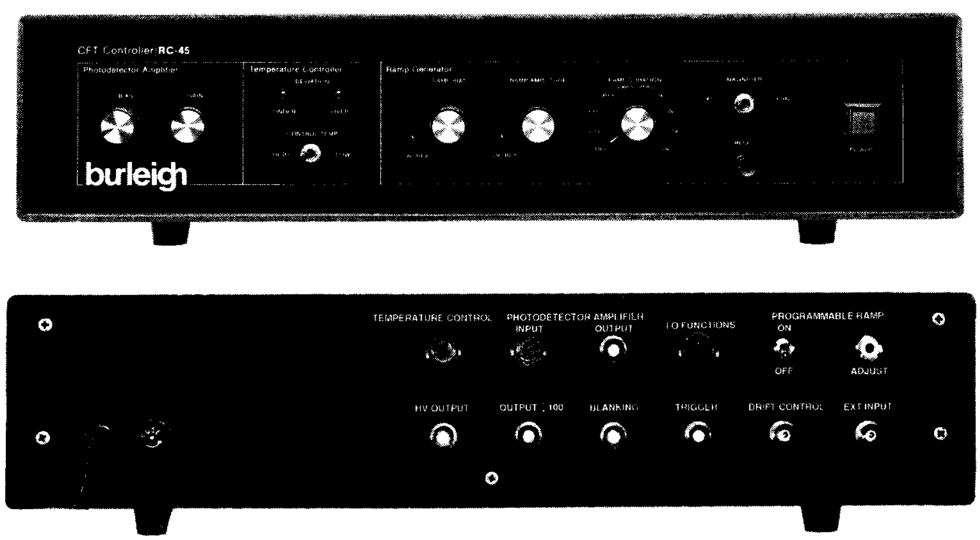

Figure 1: RC-45 Front and Rear Panels

3. OPERATION

CAUTION: The RC-45 CFT Controller is a low impedance source capable of generating voltage levels in excess of 1000 V. Do not attempt to make any connections to the controller when the unit is turned on. After turning the RC-45 off, wait 30 seconds so that any residual high voltage on the capacitive filtering circuits can discharge.

A. Initial Check

Check to see that the Ramp Generator section is operating properly before connecting to the piezoelectric device. Then 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 mid position, or about two turns from fully counter clockwise. Set the RAMP BIAS control to about 1 turn from fully counter clockwise, set the RAMP DURATION to 50 ms, and MAGNIFIER toggle switch on X1. The scope should be DC coupled. Now turn the unit on. You should observe a ramp with a baseline at ~200 V and a peak-to-peak amplitude of ~500 V. Note that the 50 ms section of the ramp is positive going. The base line can be raised or lowered with the RAMP BIAS control.

The ramp duration should be approximately 50 ms 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 the rounding, a mechanical ringing can be set up in the piezoelectric device with resultant detrimental effects. 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. With the RAMP BIAS control, it should be possible to lower the bias level as the ramp runs from about 500 to 6 V. Note that further reducing the RAMP BIAS control causes the amplifier to clip. Increase the RAMP AMPLITUDE so that the peak-to-peak ramp voltage is at least 1000 V. (At the 20 ms setting, the maximum amplitude may be slightly less than 1000 V.) The RAMP AMPLITUDE and RAMP BIAS controls should be set so that there is no clipping at the bottom or top of the ramp.

B. Operational Check

After turning the RC-45 off and waiting 30 seconds, connect the RC-45 to the piezoelectric device to be driven. Burleigh supplies a cable for connection to a Burleigh CFT Confocal Etalon.

1) Ramp Generator

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-45 on. A very faint clicking sound may be heard from the piezoelectric elements. This is normal and indicates that the RC-45 is functioning properly. (A sharp clicking indicates that the ramp is being clipped, or possibly that the piezoelectric device is arcing.) If the RC-45 is connected to a Confocal Etalon with detector and both are aligned with an appropriate radiation source (such as a laser), an output pattern should be observed from the detector output. For further instruction on how to align a confocal interferometer, consult the CFT instruction manual.

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 near 0 V and the RAMP AMPLITUDE control to near maximum. At this point, the output of the RC-45 should be ~1000 V peak-to-peak.

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. a He-Ne laser) on an oscilloscope with a collaborated linear timebase. 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 has the same width near both ends of the ramp as observed on the oscilloscope. The actual ramp output can be 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 for that range.

Figure 2 shows an uncorrected ramp. Figure 3 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 with ramp programming is 0.1% for visible PZT material, 0.5% for infrared PZT material.

2) Temperature Controller

The TEMPERATURE CONTROLLER section of the RC-45 is designed for use with Burleigh's CFT Series Confocal Etalons. The cable attached to the CFT housing is simply plugged into the rear panel TEMPERATURE CONTROL 4 pin Winchester socket, and the small grey 2 pin connector leading from the thermistor mounted on the etalon is connected to the mating socket on the CFT housing. **NOTE: Observe polarity on 4 pin Winchester connector, do not force.**

When the RC-45 is first turned on the UNDER DEVIATION LED should come on indicating that the temperature of the etalon is below that of the selected Low or High set point. After several minutes, depending on the size of the CFT system, the UNDER light will go out and possibly the OVER light will come on for a short time. This is normal and may repeat several times while the etalon temperature is stabilizing. Eventually both LEDs should stay off, indicating a stable temperature has been achieved in the vicinity of the thermistor.

NOTE: It may take several hours after both LEDs turn off for the temperature of the complete CFT Etalon to come to equilibrium.

If the OVER light comes on immediately upon turning on the power switch, it indicates an open circuit condition at the thermistor. Check that the thermistor is connected to the CFT housing via the 2 pin grey connector. If so, refer to the Troubleshooting paragraph in Section 5.

If both UNDER and OVER DEVIATION LEDs continue to alternate on and off, it indicates that the gain of the temperature control loop is set too high. This gain can be adjusted by potentiometer R9 mounted on the printed circuit board. For most precise temperature control, it should be set slightly counter-clockwise from the point at which the OVER and UNDER LEDs continue to flash.

3)Photodetector Amplifier

The photodetectors which may be purchased with Burleigh CFT Etalon systems can be plugged directly into the PHOTODETECTOR INPUT socket. The GAIN and BIAS of the signal measured at the PHOTODETECTOR OUTPUT are adjusted by the front panel controls.

For conversion from one style of detector to another (visible photodiode or infrared photoconductive detector) refer to the circuit diagrams.

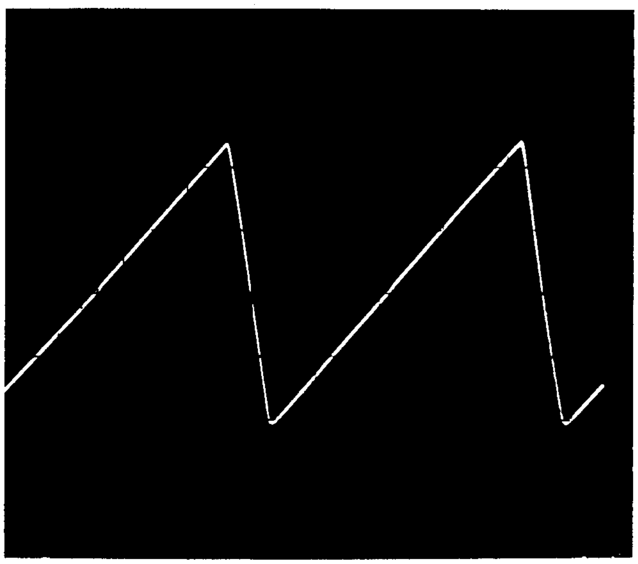

Figure 2: Ramp Waveform without correction. 1000 V amplitude, 100 msec duration

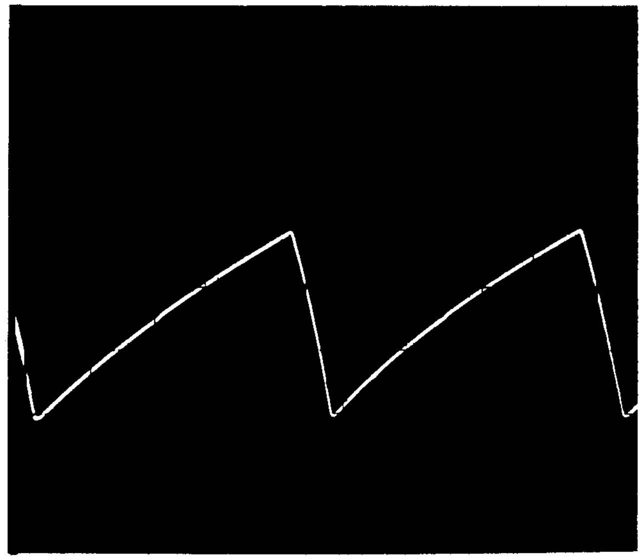

Figure 3: Ramp Waveform with programmed correction. 750 V amplitude, 100 msec duration.

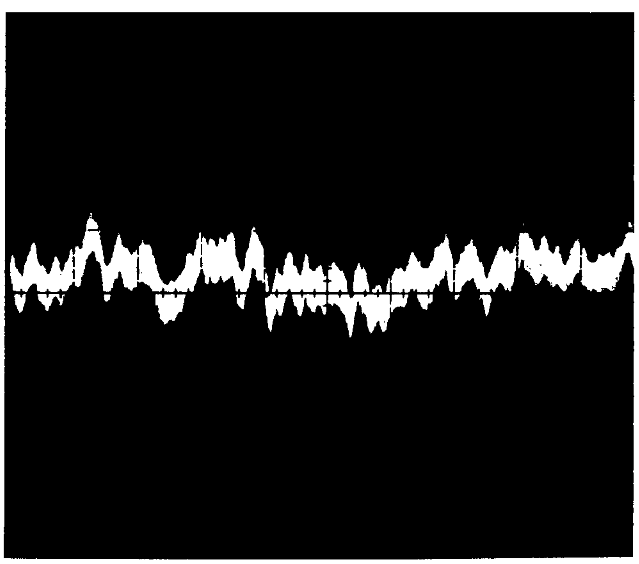

Figure 4: Noise and ripple on 16 minute ramp measured at 500 V. 40 mV p-p

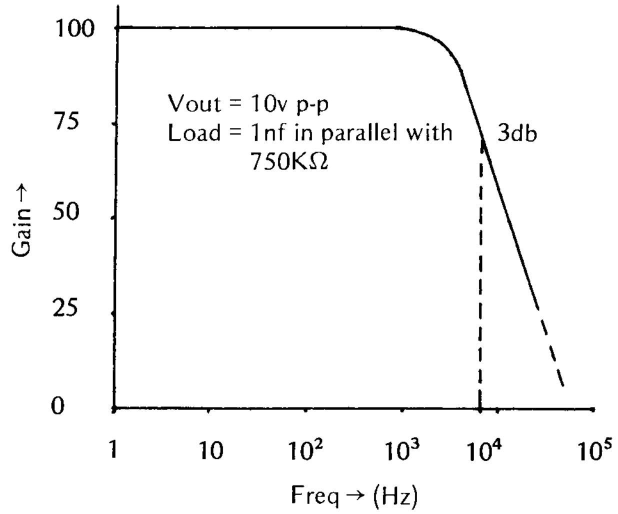

Figure 5: HV DC op amp small signal response

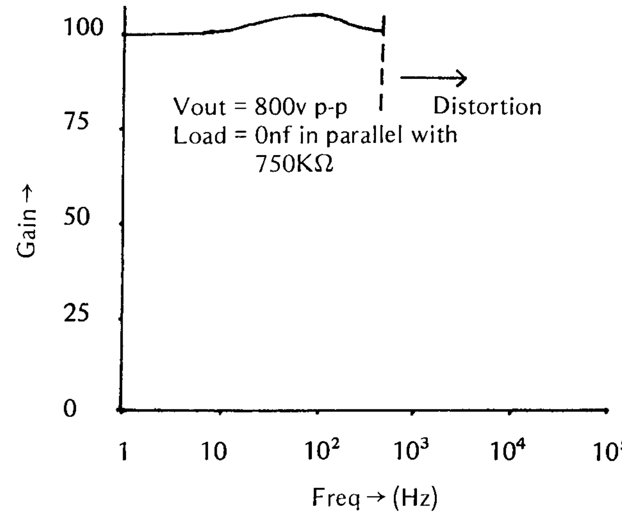

Figure 6: HV DC op amp large signal response

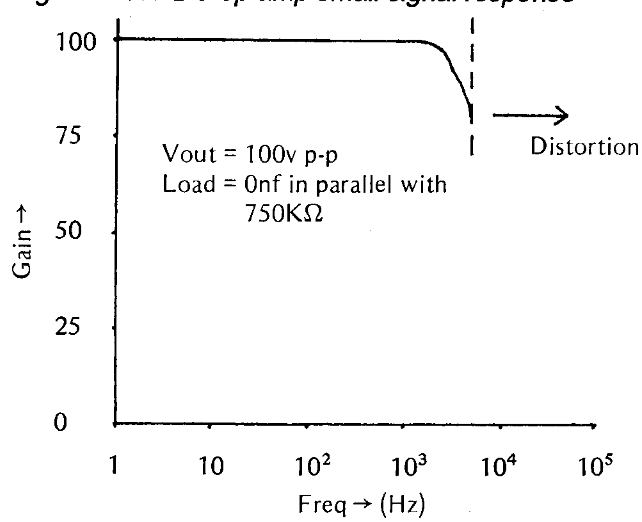

Figure 7: HV DC op amp response for 0 nF load

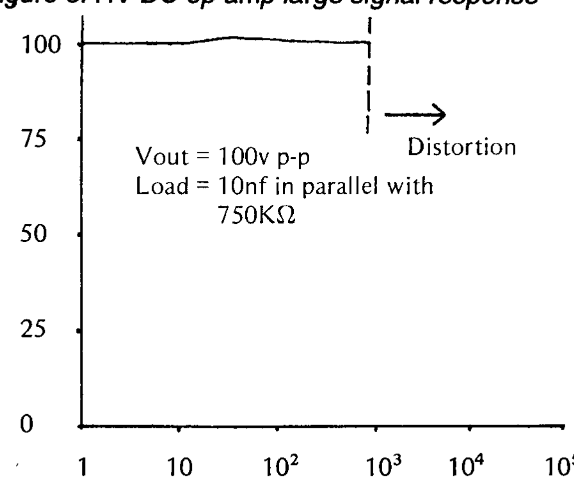

Figure 8: HV DC op amp response for 10 nF load

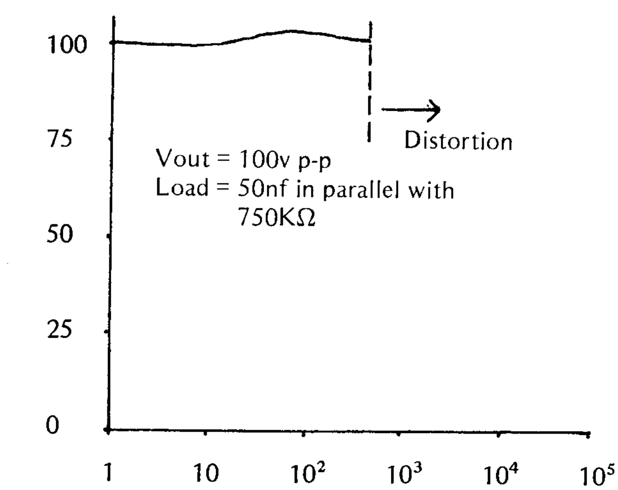

Figure 9: HV DC op amp response for 50 nF load

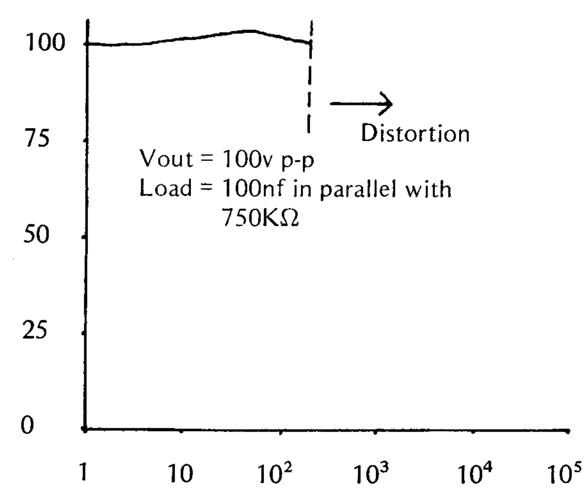

Figure 10: HV DC op amp response for 100 nF load

4. PERFORMANCE

Ramp linearity is one of the more important specifications in the RC-45. 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 4 shows ramp linearity for a 500 ms ramp rate. The measured integral non-linearity is less that 1/2% between the 10% and 90% points. The rounding observed is designed into the RC-45 to prevent mechanical ringing of the optic being driven on retrace.

Noise characteristics of the RC-45 CFT Controller are also important. Low signal recording of data requires not only a stable optical system but also a low noise electronic driver. The RC-45 has extremely low noise and ripple, less that 30 mV RMS (70 mV p-p) typical as shown in Figure 11.

The other major performance characteristics of the high voltage DC op amp in the RC-45 are depicted in figures 5 through 10. It should be noted that the RC-45 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 this data will enable the user to optimize the operation in their system.

Figures 5 through 10 show gain vs 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.

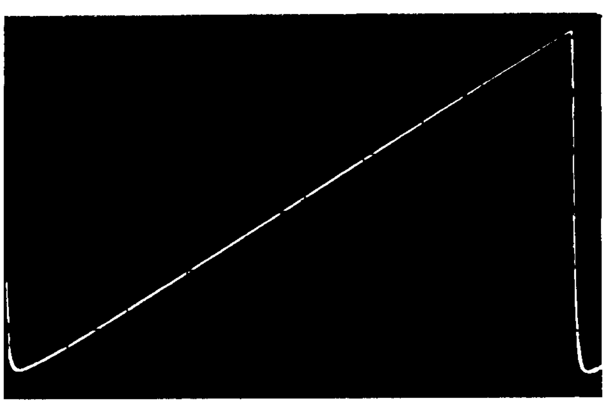

Figure 11: 0 to 1000 V ramp, 500 msec duration, integral non-linearity ≤ 1/2 % from 10% to 90% point.

5. SERVICING

Servicing should be carried out only by skilled personnel who are thoroughly familiar with 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 diagram before troubleshooting. Most of the circuitry used here is relatively straightforward and its internal operation should be self-explanatory.

A. LV Ramp Generator

The low voltage ramp is generated by Z3 (the waveform generator chip). R32 adjusts only the ramp retrace time while R64 adjusts the total ramp time. FET Q6 discharges the timing capacitors when the reset push button is depressed. Z3 also provides square wave output which is split and buffered to provide trigger and blanking output. Comparators Z4A and Z4B select voltage points on the ramp waveform and via FET Q7 switch in the external timing resistor to accomplish segmentation.

Signals from the low voltage ramp and external input are summed at amplifier Z5A and subtracted from the quadratic correction generated when the programmable feature is used. This amplifier has a 100 KΩ potentiometer in its feedback loop and will adjust the amplitude of the signal being fed to high voltage driver Z5C. This drives Q8(BU209), giving the final high voltage output. The bias level of the output is adjusted at Z5C amplifier.

The drift amplifier Z5B 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 and buffer Z5D provides a high accuracy ÷ 100 signal. This output signal is fed back to Z8 where it is arithmetically squared, inverted, buffered and sent to Z5A to be differenced with the ramp signal to provide 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 IC voltage regulators which are output and temperature protected.

B. Temperature Control Circuit

The thermistor bridge reference voltage is generated by Z1. The instrumentation amplifier composed of Z2A, Z2B and Z2C amplifies the signal from thermistor R22 which is fed to Z2D to drive the Darlington output Q4-Q5.

The R15 and C12 feedback network integrates changes in the output to prevent oscillations. Comparator Z1B shuts down the output if the thermistor open circuits. Comparators Z1C and Z1D are the voltage level detectors that drive the "under" and "over" LEDs.

C. Photo Amplifier

The Z4D amplifier is configured to accept either a PIN photodiode for detection in the visible or an IR photoconductive detector.

D. Troubleshooting

The RC-45 CFT Controller is 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.

1) Power supply check

Test Point 1	+750 VDC
Test Point 2	+12 VDC
Test Point 3	-12 VDC
Test Point 4	+24 VDC

NOTE: To prevent destruction of digital volt meters when attempting to read high voltage supplies the following procedure is recommended: for raw high voltage measure directly across C4 and then directly across C5(C4 and C5 are made up of 2 30 μf 450 V capacitors each), readings should be approximately +750 V each (~10 V 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 a Beckman series H3010).

2) If all power supplies are functioning, check test point 5 (low voltage ramp). A ramp amplitude of ~4 V should be present. If not replace Z3 (ICL8038CCPD). It is located under an orange plastic cap, which helps maintain an isothermal environment and should be placed back in position if Z3 is replaced.

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

4) If the programmed ramp feature malfunctions replace Z8 (ICL8013CCTZ).

5) If no high voltage ramp is present replace Z5 (LM348). If it still malfunctions replace Q8 (BU209).

6) If OVER LED comes on immediately upon turning on power switch or if the heater fails to control temperature check R22 thermistor; at 25°C nominal resistance should measure 2.2 KΩ . Check voltage level at Z2D pin 14; if voltage is between 2 V and 22 V and heater fails to heat replace Q4(2N3053) and Q5(2N3055).

7) If UNDER and OVER deviation lights continue to alternately turn on and off, re-adjust gain potentiometer R9 slightly counter clockwise.

8) If no signal is observed at photodetector output with photodetector connected and exposed to radiation source, check for broken cable. Replace Z4 or photodetector.

6. SPECIFICATIONS

A. Ramp Section

AMPLITUDE	3 3/4 turn potentiometer (slip clutch)
DURATION	10 position rotary switch and toggle switch. Off, 20, 50, 100, 200, 500 ms; 1, 2, 5, 10, 50, 100, 200, 500, 1000 sec.
BIAS	3 3/4 turn potentiometer (slip clutch)
Output Voltage	+3 V to 1000 V maximum, variable
Output Current	2 mA maximum
Slew Rate	1 V/μsec maximum
Input	10 V in for 1000 V out at maximum gain
Bias	+3 to 1000 V
Noise and Ripple	30 mV RMS maximum
Long Term Stability	≤ 300 mV DC typical (24 hours)
Regulation	± .05% for line voltage 108-128 VAC
Ramp Linearity without correction	≤ 0.25% integral non-linearity between 10% and 90% points

PZT Linearity between 10% and 90% points with correction

Visible PZT material with 1.0 μm scan	Interorder non-linearity for a 0.6328 μm source:< 0.1%
Infrared PZT material with 3.0 μm scan	Interorder non-linearity for a 0.6328 μm source:< 0.5%
External Input Gain	Variable 0 - 100

B. Connectors Section

External Input	Insulated BNC
Drift Control Input	Insulated BNC
Output ÷ 100	BNC
Trigger Output	BNC
Blanking Output	BNC

High Voltage Output	BNC
Temperature Control	4 pin Winchester A) Thermistor (signal) B) Thermistor (ground) C) Heater D) Heater (ground)
Photodetector Input	5 pin Winchester A) -12 VDC B) Input D) Ground
Photodetector Output	BNC

C. Wiring for I/O Functions 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 Z4A	Blue
F) Voltage comparator input Z4B	Green

Weight	15 pounds
Dimensions	4" x 17" x 12"
Linecord	6' with standard American U.L. 3 prong plug

To convert instrument from 110 VAC to 220 VAC, turn the unit off, unplug it, and wait 2 minutes before proceeding. Remove top cover, locate switch 1 (near transformer) slide to voltage indicated by arrow, replace 2 amp S.B. fuse with 1 amp S.B. fuse. Replace cover.

7. WARRANTY

The Burleigh RC-45 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. **Before return of an instrument always call Burleigh for approval of the return.** 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.

burleigh

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