

BEFORE PROCEEDING WITH COMPLETE UNPACKING AND SETUP,
CONSULT UNPACKING AND INSPECTION INSTRUCTIONS ON PAGE 7.

model 2010
LEVEL AND FREQUENCY
DETECTOR



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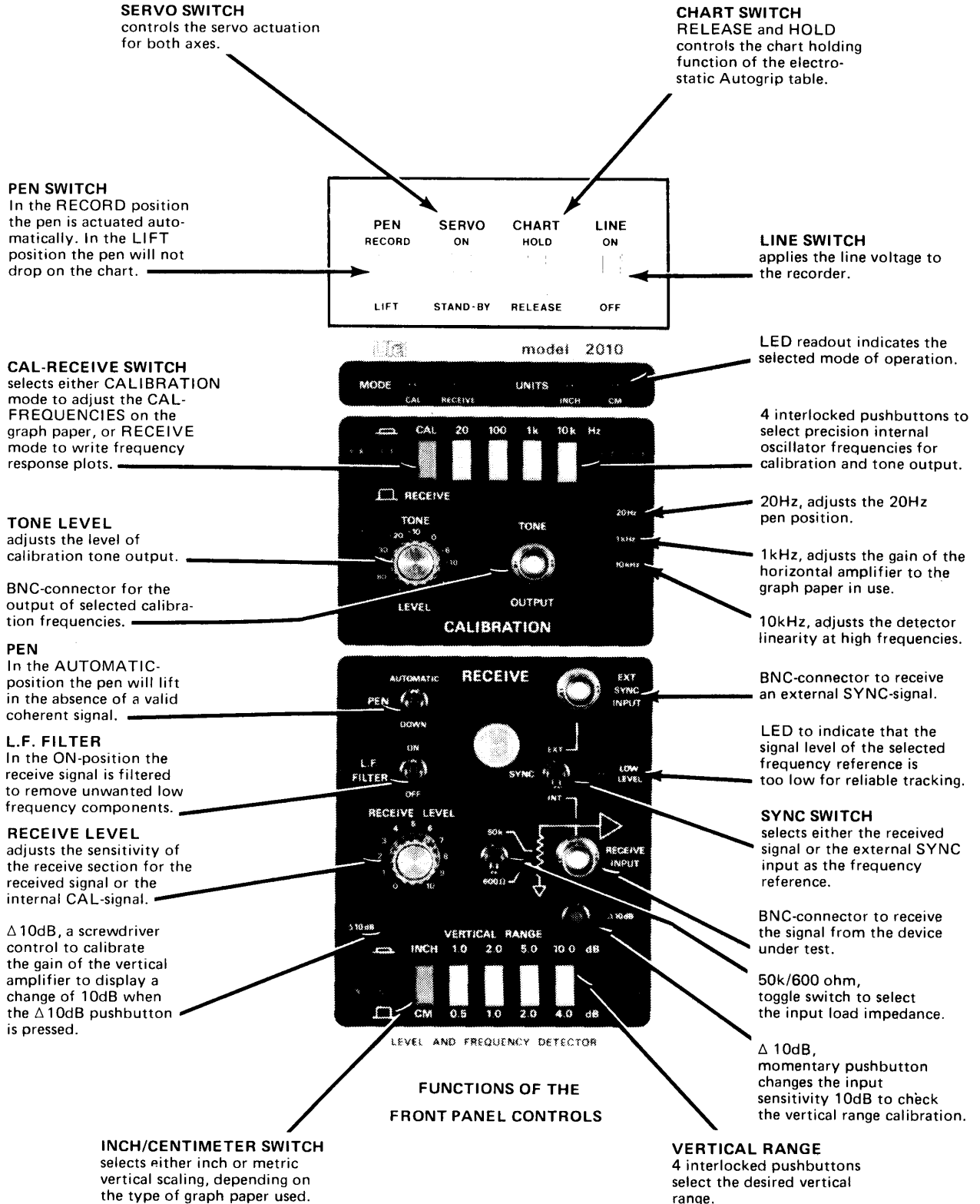
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ADDENDA

SECTION I

INTRODUCTION

1.1 FRONT PANEL



1.2 DESCRIPTION

The Model 2010 is designed to be used in the plug-in space of the Model 200, a UREI-modified Hewlett-Packard X-Y Recorder. It is also possible to use almost any oscilloscope, rather than the H.P. X-Y Recorder, for display of the Model 2010 response analysis. For instructions regarding the Recorder main frame, please refer to the separate H.P. Operating and Service Manual.

NOTE: References to the sections in the H.P. manual are quoted in brackets: < >.

The Model 2010 is designed to produce, automatically, hard copy frequency response plots with 0.05 dB resolution and more than 60 dB dynamic range. Standard 3-cycle semi-log, Keuffel & Esser audio, and Din A4 standard papers are easily accommodated. Vertical scaling can be changed from inches to centimeters by a front panel selector switch. Light emitting diodes indicate scaling units and system mode.

An important feature of the 2010 Module is the frequency detection circuit. The circuit is able to distinguish between coherent test signals and random (stochastic) signals such as voice announcements on records and tapes. During signal interruptions, the last measured frequency is stored in a memory which holds the X-Y Recorder's carriage arm in position until the system detects a new frequency and automatically updates itself. Also, during interruptions or random signals, such as announcements, the pen is automatically lifted from the paper to avoid invalid markings on the response plot.

The frequency detection circuit may be synchronized from either the input signal or from a different external source. This enables the user to plot channel separation, crosstalk between tape head sections, and similar parameters. The built-in Low Frequency Filter may be used to improve the signal-to-noise ratio of certain pre-recorded signal sources. For example, when measuring crosstalk with a test records having unusually high rumble content, use of the Filter results in a more accurate crosstalk measurement.

The audio response measurement system comprised of the Model 200 X-Y Recorder with the Model 2010 Plug-In Module performs the plot automatically and is easy to use. However, a thorough understanding of the system can only benefit the user so we recommend that the user carefully read this manual describing the 2010 Module, and also the H.P. Operating Manual which was prepared for the X-Y Recorder main frame.

1.3 APPLICATIONS

The Model 2010 Module was designed to perform frequency response measurements of audio devices. The Model 2010 has various calibration frequencies, plus a calibrated gain check, so repeatable accuracy is assured. Because the 2010 has wide dynamic range capability, sensitivity that can be adjusted to function with a wide range of signal levels, and adjustable resolution, the system is compatible with most audio equipment. Many devices can be tested without need for any additional instrumentation. What's more, the graph copy provides a permanent record for later reference. These features make the 2010 an excellent choice for regular maintenance work, quality control and performance checks, as well as for basic research and development of all types of audio equipment. Typical applications include response measurements of tape recorder/reproducers, phono cartridges, tone arm resonances, stylus wear, transmission lines, delay lines, optical/magnetic sound heads, and complete audio systems.

1.4 PERFORMANCE SPECIFICATIONS

DISPLAY UNIT

INPUT SENSITIVITY: Vertical, 1.0 volts/inch;
Horizontal, 0.1 volts/inch.

TYPE OF INPUT: Connectors to accept UREI
plug-in modules.

MODEL 2010 LEVEL AND FREQUENCY DETECTOR

RECEIVE SECTION

SENSITIVITY: 50 mV RMS for 0 dB
reference at center of Y axis.

INPUT IMPEDANCE: 50 kohm or 600 ohm,
switch selectable.

INPUT ATTENUATOR RANGE: >60 dB, continuously variable.

DYNAMIC RANGE: 64 dB (displayed).

(RECEIVE SECTION, continued)

VERTICAL RANGE: 1 dB, 2 dB, 5 dB, 10 dB/inch;
0.5 dB, 1 dB, 2 dB, 4 dB/cm.

VERTICAL RANGE CHECK: Δ 10 dB, calibrated to ± 0.1 dB.

DISPLAY ACCURACY: ± 0.1 dB, 20 Hz to 20 kHz;
 ± 0.5 dB, L.F. Filter ON.

CALIBRATION STABILITY: $\pm 1\%$ / 24 hours (after warmup).

SIGNAL DETECTION: Any coherent signal with S/N ratio
of 30 dB or greater.

FREQUENCY RANGE: 20 Hz to 20 kHz.

SWEEP SYNCHRONIZATION: Internally from received signal,
or externally from SYNC input.

SYNC SIGNAL INPUT: 20 millivolts to 10 volt RMS.

SYNC INPUT IMPEDANCE: 10 kohm.

L.F. FILTER: 12 dB/octave tracking filter;
for removing low frequency
components from the signal.

INPUT & OUTPUT CONNECTORS: BNC connectors.

CALIBRATION SECTION

TONE OUTPUT: Sine wave.

TONE LEVEL: -50 dBm to +14 dBm,
continuously variable.

OUTPUT IMPEDANCE: ≤ 3 kohm.

DISCRETE CALIBRATION FREQ: 20 Hz, 100 Hz, 1 kHz, 10 kHz, $\pm 1\%$.

AMPLITUDE UNIFORMITY: ± 0.5 dB, 20 Hz to 10 kHz.

OVERALL

ENVIRONMENTAL CONDITIONS: +10°C to +40°C,
0 to 80% relative humidity.

POWER REQUIREMENTS: Power supplied by Display Unit.

(2010 MODULE, continued)

WEIGHT: Net, 2.0 lbs (0.91 kg);
Shipping, 3.0 lbs (1.36 kg).

DIMENSIONS: 3.8" x 8.2" x 3.2" (depth behind
panel); 96.5 x 208.3 x 81.3 mm.

1.5 CONTROLS - X-Y RECORDER, DISPLAY UNIT

PEN SWITCH: A two-position slide switch controls the lowering and raising of the pen. In the RECORD position the pen is actuated automatically through the pen lift logic. In the LIFT position, the pen will not drop.

SERVO SWITCH: A two-position slide switch controls the servo actuation for both axes.

CHART SWITCH: A two-position slide switch, RELEASE and HOLD, controls the chart holding function of the electrostatic Autogrip table.

LINE SWITCH: A two-position slide switch applies the line voltage to the recorder.

1.6 CONTROLS - MODEL 2010

CAL-RECEIVE: Push-push button to select either CAL or RECEIVE mode.

4 PUSHBUTTONS: Interlocked, to select precision internal oscillator frequencies for calibration of X-Y recorder.

TONE LEVEL: Continuously variable control adjusts level of calibration tone output.

RECEIVE LEVEL: Continuously variable control adjusts input sensitivity.

50 k/ 600 ohm: Toggle switch selects input termination.

- Δ 10 dB: Momentary pushbutton changes the input sensitivity 10 dB to check the vertical range calibration.
- INCH/CM: Push-push button selects inches (english) or centimeters (metric) vertical scaling.
- VERTICAL RANGE: 4 interlocked pushbuttons select calibrated vertical ranges.
- SYNC SWITCH: Toggle switch selects either the received signal or an external SYNC input as a frequency reference for horizontal position.
- LOW LEVEL LED: If the signal level of the selected frequency reference is too low for reliable tracking, this LED will be turned ON.
- L.F. FILTER SWITCH: When this toggle switch is ON, the receive signal is filtered to remove unwanted low frequency components.
- PEN SWITCH: Toggle switch; in AUTOMATIC position, the pen will lift in the absence of a valid coherent signal. In DOWN position, this function is disabled and the pen will remain in writing position.
- SCREWDRIVER ADJUSTMENTS: Various calibration adjustments which are detailed in Section 3.

1.7 ACCESSORIES

UREI Instruction Manual

K & E Audio Frequency Graph Paper #46 6882
(UREI order number: 200 G).

Metric paper for use on the X-Y Recorder has the following specification:

"Logarithmic Frequency Paper for Audio Conception,"
according to LB DIN 45 408, Number 666 356, 437-1/2.
(UREI does not stock this paper).

SECTION II

INSPECTION AND INSTALLATION

2.1 UNPACKING AND INSPECTION

The Model 2010 Level and Frequency Detector Module is normally packed in a small carton, and is not installed in the Display Unit. For installation in the Display Unit, also see the H.P. Operating Manual <Section II>.

The instrument was carefully packed at the factory, and the container was designed to protect the unit from rough handling. Nevertheless, we recommend careful examination of the shipping carton and its contents for any sign of physical damage which could have occurred in transit.

If damage is evident, do not destroy any of the packing material or the carton, and immediately notify the carrier of a possible claim for damage. Shipping claims must be made by the consignee.

The shipment should include:

Model 2010 Level and Frequency Detector Module

UREI Instruction Manual

Two-part Warranty Card bearing the same serial number as the plug-in module

2.2. ENVIRONMENTAL CONSIDERATIONS

The system will operate satisfactorily over a range of ambient temperatures from +10°C to +40°C (+50°F to 104°F), and up to 80% relative humidity.

If the system is installed in an equipment rack together with high heat producing equipment (such as power amplifiers), adequate ventilation should be provided to prolong the life of components. Also, while circuitry susceptible to hum pick-up is sufficiently shielded from moderate electromagnetic fields, installation should be planned to avoid mounting the system immediately adjacent to large power transformers, motors, etc.

To comply with existing U.S. electrical codes, the Display Unit is supplied with a three-wire power cord, the grounding pin of which is connected to the chassis. For this reason, where a significant potential difference exists between AC conduit ground and either the device under test or the grounded metal enclosure in which the chassis is installed, ground-loops may occur. If hum is experienced, the possibility of ground-loop pick-up may be checked

by using a 3-wire to 2-wire AC adaptor at the power receptacle. Caution is advised while operating the system with the AC plug ungrounded.

2.3 OPERATING POWER

For correct connection of the Model 2010/Model 200 system to the AC power source, refer to the H.P. manual <paragraph 3-7 and figures 3-2 and 3-5>. The Model 2010 Plug-In Module receives its power from the Display Unit, via card edge connectors. No additional voltage selections are necessary. If the Model 2010 module is not used in conjunction with the Model 200, then power must be supplied according to the specifications in Section 4.8.

2.4 RACK MOUNTING ACCESSORY

The 200 X-Y Plotter may be mounted with brackets in a standard 19-inch rack. Only those screws which are packed with the mounting kit should be used to fasten the brackets to the plotter. (Longer screws could damage the plug-in module.) Also see the H.P. Operating Manual <figure 2-1>.

2.5 EXTERNAL CONNECTIONS

The BNC connectors for the tone output and the receive section inputs are located on the Model 2010's front panel. These connectors remain accessible at all times, even if the Recorder is permanently installed in a rack.

SECTION III

OPERATING INSTRUCTIONS

3.1 GENERAL

As suggested in the introduction, the user is advised to read the appropriate section of the H.P. Operating Manual for the X-Y main frame <paragraphs 3-17 to 3-26>, or of the manual for any other display unit.

The Model 2010 Plug-In Module should never be inserted or pulled out of the main frame while power is ON (LINE switch should be OFF).

3.2 CALIBRATION

Perform the calibration procedure before plotting a graph. The procedure assures that the plotting system is operating under optimum conditions and that the specified accuracy will be obtained.

An initial warm-up period of 5 minutes is sufficient before the actual calibration is performed. During long periods of continuous use, the calibration points should be checked occasionally to be sure that the instruments have not drifted.

3.3 PAPER ALIGNMENT AND HORIZONTAL CALIBRATION SETTINGS

3.3.0 MODEL 2010 USED TOGETHER WITH X-Y RECORDER MODEL 200.

A paper stop protrudes at the lower left corner of the platen. It is helpful for alignment of the paper provided, Audio Frequency 46 6882 (UREI 200G). For alignment of the DIN A 4 paper, the left edge of the platen is used as a reference, and the paper stop may be removed.

The calibrated frequencies (20 Hz, 100 Hz, 1 kHz and 10 kHz) are used to adjust the 2010 module to drive the plotter in the correct relationship with the paper grid in use. Set the controls as follows:

- CAL-RECEIVE: Select CAL mode by pushing the button down.
- TONE LEVEL: Set control approximately at 0 dB position. (Does not affect CAL amplitude on the display unit.)
- SYNC SWITCH: Set toggle switch at INT position.
- RECEIVE LEVEL: Turn control clockwise until the pen moves into the display area.

50 k/ 600 Ω : Set the toggle switch at 50 k for high impedance (bridging), or at 600 Ω for low impedance, depending on the termination requirements of the device under test.

VERTICAL RANGE: Select 10 dB (10.0 dB button in).

INCH-CENTIMETER: Engage the button for INCH display (button in).

3.3.1 20 Hz CAL.

In the 20 Hz position, the frequency calibrator is set for the left hand reference of the graph paper, the beginning of the plot. The adjustment is made by inserting a small, slotted screwdriver through the opening in the front panel marked "20 Hz."

The range of adjustment is approximately 1.25 inches (3.5 cm) from the left side mechanical stop of the pen carriage.

NOTE: In the CAL mode, the pen is automatically lifted. It is helpful during calibration to mark the adjustments with a dot. After adjusting the control to obtain the correct pen position, push lightly on the cover of the pen carriage just until the pen marks the graph paper.

3.3.2 1 kHz CAL.

This screwdriver adjustment is also accessible through a hole in the front panel, and it affects the DC gain to the recorder's horizontal amplifier. After pushing the 1 kHz CAL switch, the pen carriage will move horizontally to approximately the middle of the chart area. When adjusted properly, the pen should be positioned directly above the 1 kHz grid line of the graph paper. The adjustment range is approximately 1.25 inches.

3.3.3 10 kHz CAL.

After pushing the 10 kHz CAL switch, the carriage will move to the right. The front panel screwdriver adjustment affects the linearity of the logarithmic voltage converter. Only an occasional check of the 10 kHz CAL position will be necessary. The adjustment range is approximately 0.25 inches.

Since there is an interaction between the 10 kHz and the 1 kHz adjustments, the two adjustments should be alternately repeated until alignment of both frequencies has been achieved.

3.3.4 100 Hz CAL.

There is no adjustment provided for the position of the 100 Hz frequency reference. When 100 Hz is selected, the pen should align properly if the other adjustments have been performed according to the foregoing instructions. A 100 Hz reference is of value primarily when using an oscilloscope for display.

3.3.5 SUMMARY.

The "20 Hz" adjustment is the actual zero position of the recorder's X-axis; it may be regarded as a mechanical alignment of the pen over the 20 Hz line on the graph paper.

The "1 kHz" adjustment correlates the gain of the horizontal amplifier with the graph paper in use.

The "10 kHz" adjustment is performed only occasionally, or if the linearity of the frequency sweep has drifted. Since "10 kHz" affects linearity of the full sweep, "1kHz" must be re-checked.

The "100 Hz" CAL frequency provides a spot check in the lower section of the frequency range, and is not intended for any adjustment.

3.3.6 X-AXIS CALIBRATION TO A DISPLAY UNIT OTHER THAN THE MODEL 200 X-Y RECORDER.

Almost the same procedure described in Sections 3.3.0 through 3.3.5 may be followed for calibration to a different display as, for example, the CRT screen of an oscilloscope.

In the event an oscilloscope serves as the display unit, the "100 Hz" CAL position assumes more importance since it is used to calibrate the H.F. linearity at 10 kHz; that is, the 1-decade increment from 1 kHz to 10 kHz (on the screen) should be the same as the 1-decade increment from 100 Hz to 1 kHz. If, after the Model 2010's gain has been adjusted for proper 1 kHz position, both 1-decade segments do not cover equal length on the screen, then the Model 2010's "10 kHz" CAL must be adjusted for proper linearity.

This concludes the calibration of the horizontal axis (X-axis).

3.4 VERTICAL CALIBRATION (Δ 10 dB GAIN CALIBRATION)

The INCH-CENTIMETER switch should be in the vertical position specified for the type of graph paper (or the CRT graticule) in use. The vertical gain may be adjusted with a small, slotted screwdriver through the front panel hole marked " Δ 10 dB" until the pen movement (or scope trace) indicates a change of 10 dB when the momentary Δ 10 dB pushbutton is depressed.

The above adjustment is best performed in that vertical sensitivity range in which the full 10 dB change can be displayed on the paper (or on the CRT screen). For example, a range of 2 dB/inch produces a 5-inch displacement for 10 dB change, and a range of 1 dB/cm produces a 10 cm displacement for a 10 dB change.

3.5 CALIBRATION TONE OUTPUT

The calibration tone signal is available at the BNC connector marked "Tone Output". The wave form is sinusoidal, and its frequency corresponds to the selected CAL pushbutton. The amplitude is variable from -60 dB to +14 dB, using the TONE LEVEL control. The calibration tone may be used to check the function of audio equipment used in the test. It also may be used to record pilot tones on tapes, to check transmission lines, etc. However, the tone's purity is insufficient for use in distortion measurement.

3.6 POST-CALIBRATION PROCEDURES IN PREPARATION FOR RESPONSE PLOTTING

After the system is calibrated and the device under test is connected, the Model 2010 is ready to generate the frequency response plot. All controls are on the front panel, and the operating status can be checked easily by the position of the controls and/or the LED Mode indicators.

PRECAUTION WHEN USING THE X-Y RECORDER: To avoid unnecessary wear on the Balance potentiometers and on other mechanical parts, the SERVO slide switch should be in STAND-BY position when not recording. If the input voltage exceeds the vertical range setting, the pen will move off scale. The motor will stop, and the recorder is protected against damage until the signal level returns to an on-scale value.

3.6.1 RECORDER PEN LIFT OR OSCILLOSCOPE TRACE & BLANKING.

When the PEN slide switch, which is part of the Model 200 X-Y main frame, is placed in LIFT position, it will override all writing functions. This enables the operator to make a "dry run" before committing the plot to paper. With the switch in the RECORD position, the pen will drop on the paper if the following three conditions are met:

1. coherent signal is sensed at the Model 2010 input,
2. the signal frequency is equal to or greater than 20 Hz, and
3. the detected input amplitude is sufficient for on-scale display at 10 dB/inch (or 4 dB/cm) sensitivity range.

NOTE: The same conditions have to be fulfilled to display a trace on the CRT of an oscilloscope.

The PEN toggle switch, which is part of the Model 2010 Plug-In Module, usually remains in the AUTOMATIC position. In this mode, the pen will lift off the paper (or the scope trace will blank) automatically if no useful signal is present, but the pen remains in writing position (or the scope trace remains steady) if a continuous frequency is applied to the receive input. Thus, because the presence of a continuous frequency could result in an ink blot, and possibly a stain on the recorder platen or a burn on the CRT of an oscilloscope, the Model 200's PEN LIFT switch should be in LIFT position (or the scope's INTENSITY should be decreased) when plots are not being made.

Under certain conditions it may be desirable to force the pen down (or to prevent blanking on an oscilloscope) so that all received signals are displayed. This might be valuable, for example, when using a pink noise input. To force the pen down (or to prevent blanking), set the PEN switch to DOWN position.

3.6.2 OFF-SCALE SIGNAL AMPLITUDES.

If the amplitude falls below the minimum displayed range before the last test frequency has been reached, and the amplitude later comes back to a usable level, the horizontal display position will be automatically updated before response plotting resumes. This low level condition is also indicated by an illuminated "Low Level LED" (see paragraph 4.5.2).

3.6.3 SYNC SIGNALS & SYNC SWITCH.

There may be cases when the signal-to-noise ratio of the receive input signal is not sufficient to reliably trigger the frequency sensing circuit. However, a clean signal which is a

synchronous replica of the noisy signal may be available. For instance, when plotting crosstalk measurements, the output of an undriven channel of a phono preamp or tape head preamp may be very noisy. In this case, the channel with maximum signal amplitude (the driven channel) should be connected to the Model 2010's EXT SYNC INPUT, and the SYNC toggle switch should be moved to the EXT position. The noisy channel (undriven channel) would remain connected to the RECEIVE INPUT.

3.7 PLOTTING A GRAPH WITH THE MODEL 200 X-Y RECORDER AND THE MODEL 2010 PLUG-IN MODULE SYSTEM.

3.7.0 INITIAL CONTROL SETTINGS.

NOTE: Except for the purpose of exchanging a plug-in module, the LINE switch should remain ON while working with the recorder. This assures warm-up and avoids drift.

<u>SWITCH OR CONTROL</u>	<u>SETTING</u>
PEN slide switch	RECORD
SERVO slide switch	ON
CHART slide switch	HOLD
LINE slide switch	ON
CAL-RECEIVE switch	RECEIVE
SYNC toggle switch	Select for frequency tracking, either INT (from RECEIVE SIGNAL INPUT) or EXT (from EXT SYNC INPUT).
RECEIVE LEVEL control	Adjusted for convenient display of the graph.
INPUT IMPEDANCE switch	Set for correct termination (loading) of the device under test.
VERTICAL RANGE switches	Select to achieve the desired graph or display resolution, within the limits imposed by the paper.
INCH/CM switch	Set as required for scaling of the graph, depending on the paper in use.
PEN toggle switch	Usually in AUTOMATIC; for exceptions, see Section 3.6.1.

L.F. FILTER switch Usually ON, except when examining
rumble or when absolute value of low
frequency components is critical.

3.7.1 CONNECTIONS.

Supply the signal to be displayed through the RECEIVE INPUT BNC connector. If an external signal is to be used to drive the frequency sensing circuit, supply that signal through the EXT SYNC INPUT BNC connector.

3.8 PLOTTING RESPONSE WITH THE MODEL 2010 PLUG-IN MODULE AND AN OSCILLOSCOPE DISPLAY UNIT

3.8.0 INITIAL CONTROL SETTINGS.

NOTE: Except for the purpose of exchanging a plug-in module, the power should remain ON until the test session is over. This assures warm-up and avoids drift.

<u>SWITCH OR CONTROL</u>	<u>SETTING</u>
VERTICAL GAIN (scope)	1 volt/division, typical.
HORIZONTAL GAIN (scope)	0.75 volts/division, typical.

NOTE: Horizontal Calibration is performed with the CAL frequencies, Section 3.3.1 - 3.3.6.
Vertical Calibration is performed with the $\Delta 10$ dB pushbutton feature, Section 3.4.0.

CAL-RECEIVE switch	RECEIVE
SYNC toggle switch	Select for frequency tracking, either INT (from RECEIVE SIGNAL INPUT) or EXT (from EXT SYNC INPUT).
RECEIVE LEVEL control	Adjusted for convenient display on the scope (in conjunction with the scope's vertical gain and vertical position controls.)
INPUT IMPEDANCE switch	Set for correct termination (loading) of the device under test.
VERTICAL RANGE switches	Select to achieve the desired display resolution within the limits imposed by the scope's gain and screen.

INCH/CM switch	Set as required for scaling of the graph, depending on the CRT graticule in use.
L.F. FILTER switch	Usually ON, except when examining rumble or when absolute value of low frequency components is critical.

3.8.1 CONNECTIONS BETWEEN MODEL 2010 AND EQUIPMENT UNDER TEST.

Supply the signal to be displayed through the RECEIVE INPUT BNC connector. If an external signal is to be used to drive the frequency sensing circuit, supply that signal through the EXT SYNC INPUT BNC connector. (Same procedure when using X-Y Recorder)

3.9 RESPONSE PLOTTING CHARACTERISTICS

To make the response measurement, initiate the input (and any external SYNC) signal, and the display unit will begin tracing the response. There is a delay of approximately 1 second, from the onset of the input signal to the initiation of display, an acquisition time during which the Model 2010 senses the input frequency and sets the proper drive voltage for the X-axis. The frequency response plot will continue until such time as either:

1. the input signal is interrupted, or becomes incoherent;
2. the amplitude falls below the minimum level;
3. the frequency becomes less than 20 Hz.

3.10 ANALYSIS OF PLOTTED GRAPHS

As a general rule, one should document X-axis and Y-axis parameters on the completed graph for later references. Notes should include vertical sensitivity, signal source, scale factor (inch/cm), L.F. filter setting, termination, and any other conditions existing during the plot.

Given the information suggested above, the interpretation of a single graph or of comparative graphs becomes a simple matter of reading the numbers off the paper. If several graphs are plotted on the same sheet of paper, use of different colors can facilitate identification of the curves.

Sometimes it is necessary to investigate a small segment of the graph with an expanded amplitude resolution. Such a graph can be plotted by using a more sensitive VERTICAL RANGE setting (fewer dB per unit of height). Thus, more detail will be obtained in portions of the graph, although in other portions of the plot, the pen may reach the edge of the paper.

3.11 SAMPLE GRAPHS

Figures 1 through 4 are graphs selected to give some examples of using available pre-recorded test records for the analysis of magnetic pickup response and crosstalk.

The vertical sensitivity is 10 dB/inch on each graph. Figures 1, 2 and 3 are obtained from the CBS Stereophonic Test Record STR 100. The characteristic of the recording is constant amplitude from 40 Hz to 500 Hz, and constant velocity from 500 Hz to 20,000 Hz at 0 dB level.

Figure 1 is a frequency sweep of the left channel and the crosstalk (stereo separation) in the right channel, played through a flat preamplifier. NOTE: To plot the crosstalk in the right channel, the signal from the left channel was connected to the EXT SYNC INPUT; see Section 3.6.3.

Figure 2 is a similar graph. However, it is plotted from a band which contains voice announcements and spot frequencies in reverse order: that is, 20,000 Hz to 20 Hz.

Figure 3 is the same band as in Figure 1, played back through a preamplifier with a standard RIAA characteristic.

Figure 4 shows the effects of the low frequency filter (see also Section 4.3.2). The frequency source for the graph is the Frequenz-Mess-Schallplatte, DIN 45 541, with a frequency sweep recorded at -10 dB level from 31.5 Hz to 1,000 Hz, and at -20 dB level from 1,000 Hz to 20,000 Hz.

The upper measurement in Figure 4 was plotted with the L.F. FILTER switch in the OFF position, and it represents the recorded channel and its apparent crosstalk in the unused channel. Note the contribution of record warp and turntable rumble to the measurement. The lower measurement was plotted with the L.F. FILTER switched ON and represents the actual crosstalk.

The graphs, Figures 5, 6 and 7, are plotted from professional tape machines. The frequency source used for Figure 5 is a Reproducer Calibration Tape with a continuous slow sweep from 20 Hz to 20 kHz at a -10 dB level. While the upper trace shows the general frequency response at a 10 dB/ inch sensitivity range, the lower trace has an expanded sensitivity of 2 dB/inch for the same frequency response plot. For further information concerning test tapes suitable for this system, contact:

Magnetic Reference Laboratory, Inc., 229 Polaris Avenue, Suite 4
Mountain View, CA 94043 Telephone (415) 965-8187

In Figure 6, a crosstalk measurement of a 2-track machine was performed as described for Figure 1.

Figure 7 is a group of record-through-play frequency response curves from a 16-track machine. All channels have been recorded simultaneously. Using the RECEIVE LEVEL control, the response curve of each individual channel was offset by 2.5 dB below the previous channel at the 1 kHz reference point.

(See page 17 for a discussion of these graphs.)

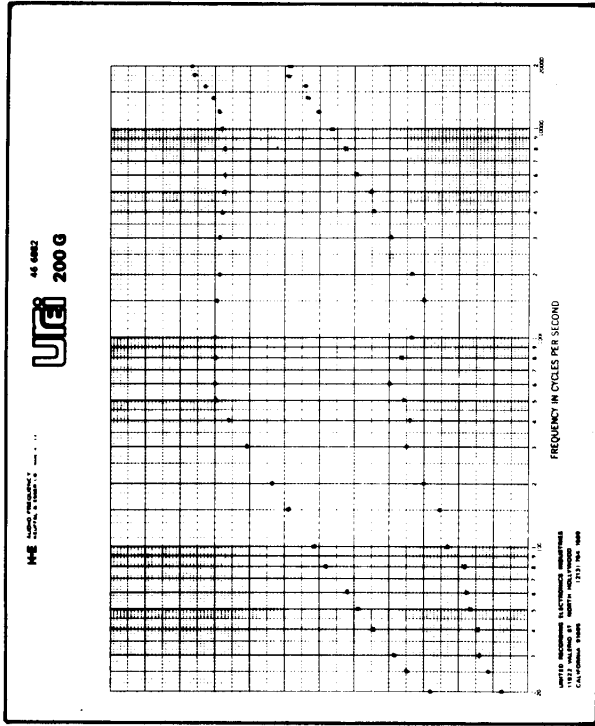


FIGURE 2.

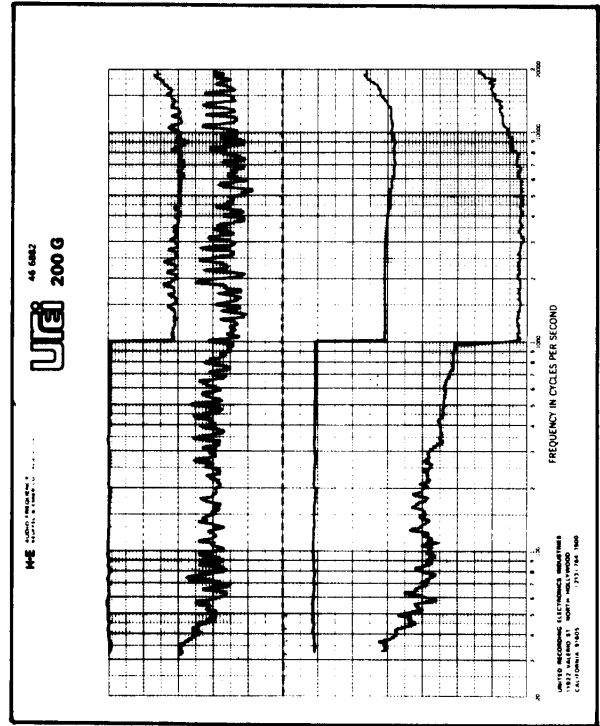


FIGURE 4.

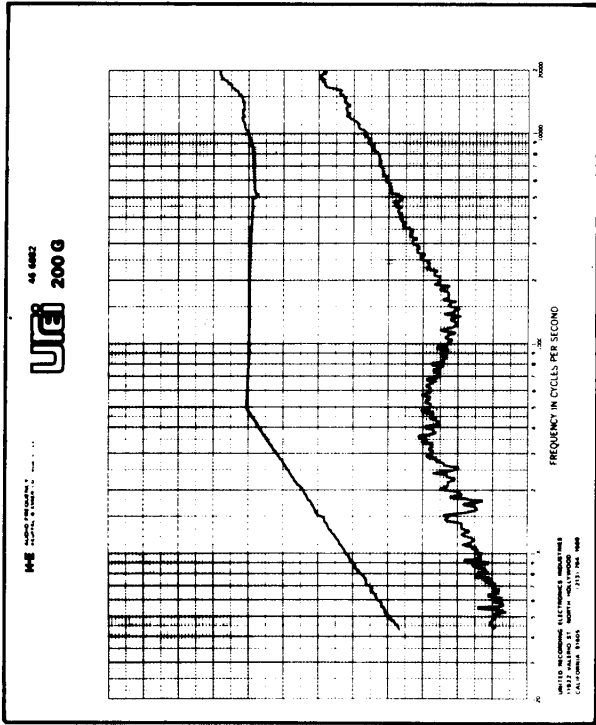


FIGURE 1.

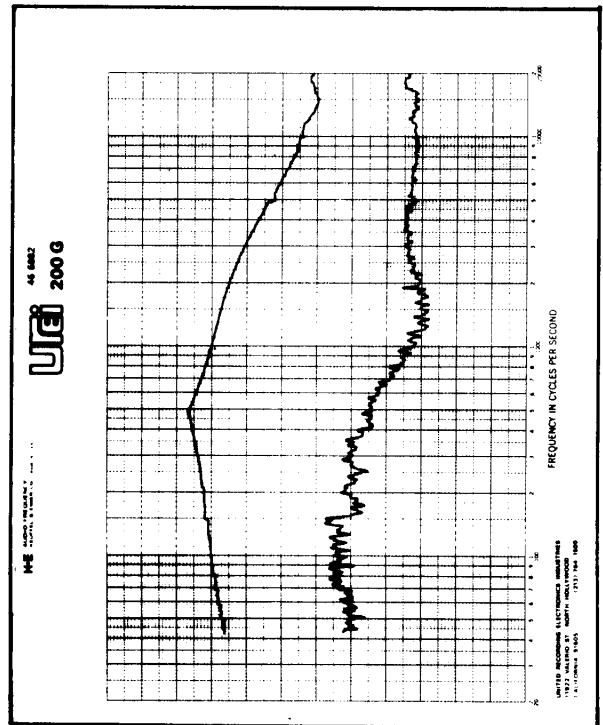


FIGURE 3.

(See page 17 for a discussion of these graphs.)

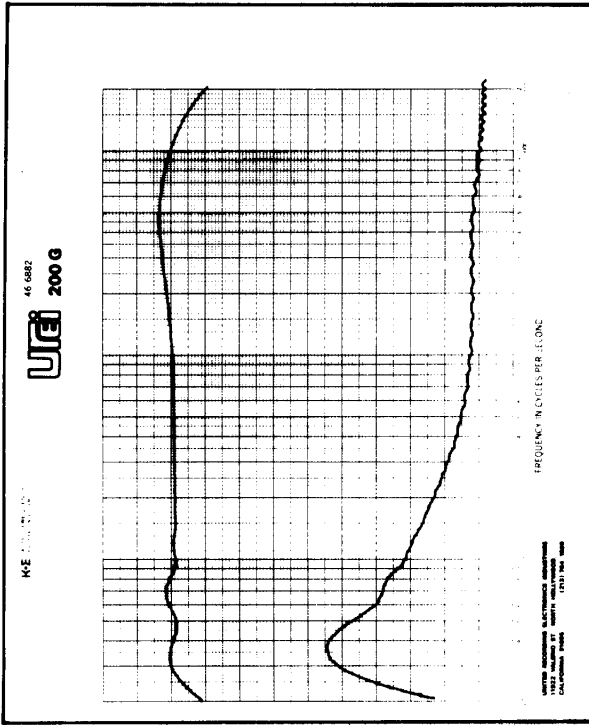


FIGURE 5.

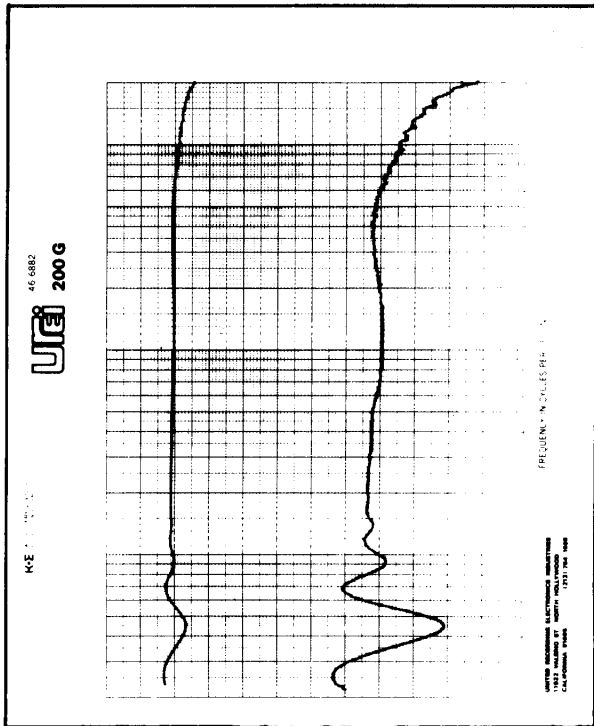


FIGURE 6.

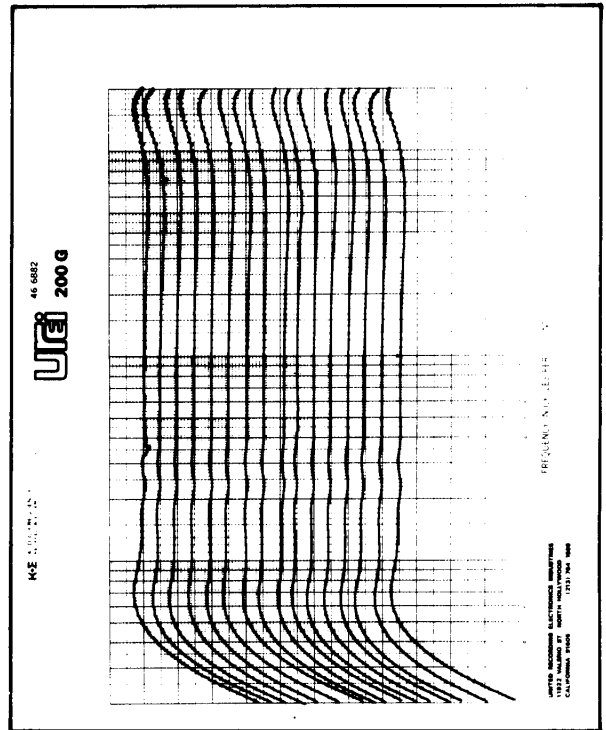


FIGURE 7.

SECTION IV

THEORY OF OPERATION

4.1 GENERAL DESCRIPTION

For the following explanation of the Model 2010 Module, refer to the block diagram, figure 8, and to the more detailed schematics, figures 9 and 10.

The Receive Circuit is fed by a signal from the device under test (RECEIVE mode) or from the internal calibration oscillator (CAL mode). The signal then passes through an input preamplifier whose gain can be changed by 10 dB if the Δ 10 dB pushbutton is activated. The signal then passes through an active high pass filter which only acts if the L.F. FILTER switch is ON. The preamplified signal is then fed to two points, an RMS Rectifier/Log Converter Circuit and the SYNC source switch. The RMS Rectifier/Log Converter output is a DC voltage which is logarithmically proportional to the amplitude of the received signal. This DC voltage is fed through a DC amplifier and through a fixed low pass filter which removes spurious components from the signal. The Δ 10 dB calibration adjustment is after the filter. The voltage then goes through the Y-output Amplifier, where the amplifier's gain can be adjusted for proper scaling (INCH/CM) and resolution (dB/unit Y-axis).

The EXT SYNC INPUT passes through a Sync-Preamp and to the EXT/INT SYNC switch. The selected signal, whether the pre-amplified RECEIVE signal or the preamplified EXT SYNC signal, is then fed to a Preamplifier/Limiter which enables the Sync Circuitry to function with signal amplitude variations of more than 60 dB. A Low Level Detection circuit turns on an LED and sends a signal to the Pen Write/Lift Logic if signal levels are below the minimum usable value. The amplitude stabilized Sync signal then passes through a tracking filter, a narrow bandpass filter which senses the frequency of the predominant signal energy and excludes higher and lower frequency components. The bandpass filtered Sync signal is then subject to shaping, and is fed to a Pulse Generator Circuit.

The Pulse Generator creates a stream of narrow pulses, the pulse rate being the same as the frequency of the processed Sync signal. A buffer amplifier then feeds the pulse train to a temperature-compensated Logarithmic Converter, which changes the pulse train to a DC voltage which is proportional to the frequency of the Sync signal. The 10 kHz CAL, a linearity adjustment, affects this Log Converter. The DC voltage passes through a DC amplifier, a Hold Circuit, an Output Amplifier, the 1 kHz CAL adjustment, and to the X-axis output.

The Pulse Generator output, the Low Level Detector output, the Symmetry Detector output, and the status of the PEN AUTOMATIC-DOWN switch are all fed to a summing gate that controls the Module's

actual Pen Lift output and causes the Hold Circuit of the Output Amplifier to respond. The following logic circuit also generates (high and low) Z-axis outputs for oscilloscope blanking purposes.

The 20 Hz CAL control is a variable attenuator that adjusts a voltage supplied from the X-Y Plotter so that pen position can be adjusted. The control is not interrelated with other circuits in the 2010 Module.

The Calibration Oscillator circuitry generates a tone of switch-selected frequency. This tone is available internally at the RECEIVE INPUT when the CAL-RECEIVE switch is in CAL position. The tone is also fed through a variable attenuator and to the BNC TONE OUTPUT connector.

The Power Supply Circuit filters the raw bipolar DC supply voltage from the X-Y Recorder main frame (or some other suitable external voltage source). The circuit then provides well-regulated bipolar voltage for the various circuits within the 2010 Module.

4.2 CALIBRATION OSCILLATOR CIRCUIT

This is a conventional, single op-amp sinusoidal oscillator circuit (IC 106). The circuit has negative and positive feedback, the FREQUENCY SELECTOR switching done in the negative A Zener diode (CR110) stabilizes the tone output voltage, regardless of variations in power supply voltage. The tone is fed to the TONE OUTPUT BNC connector via a 10 kohm log potentiometer (R3). The tone is also fed to a voltage divider (R158 & R159) which feeds the CAL position of the CAL-RECEIVE switch; the voltage divider output level is such that the Model 200 X-Y Recorder will indicate above the top of the Y-axis scale when the Model 2010 is set for its most sensitive Y-axis gain. (When the Model 2010 is set at 1 dB/inch, a -20 dB RECEIVE input drives the pen to the top of the graph paper). The voltage divider is factory preset with an internal potentiometer (R159), and does not require any user adjustments.

4.3 VERTICAL AXIS CIRCUITS

The Receive Input Preamplifier, L.F. Filter and RMS Rectifier/Log Converter are located on Input Board #500. Remaining Vertical Axis Circuits are located on the Y-Channel board #300 and the Sensitivity Range Switch board #400.

4.3.0 RECEIVE INPUT.

The incoming signal is fed to the high side of the 50 kohm RECEIVE LEVEL potentiometer (R2). This provides the "50 k" termination of the "50 k/600 Ω " switch. The 600 ohm termination is provided by shunting a 604 ohm resistor (R1) across the incoming signal.

4.3.1 INPUT PREAMPLIFIER.

The arm of the RECEIVE LEVEL pot feeds the Input Preamplifier (IC501 A), which is located on Input Board #500 (a plug-in circuit board which provides electronic isolation to minimize noise in the low-level input circuitry). The Input Preamp normally has a gain of 6.2 dB, but pressing the Δ 10 dB button changes the preamp's negative feedback to produce a precise gain increase of 10 dB, to a total of 16.2 dB.

4.3.2 L.F. FILTER.

Following the Input Preamp, the signal passes through the L.F. Filter Circuit. This 2-pole tracking filter consists of two op-amps (IC501B and IC501C) and a combination LED/LDR in which one light emitting diode controls two optically-coupled light-dependent resistors (OCR 501). The LED is fed by the output of the Pulse Generator (IC101, pin 9), so its time-averaged brightness is proportional to the predominant frequency of the Receive Input signal. The more light, the lower the resistance of the LDR's, and hence the higher the cutoff frequency of the two filter poles (C503/LDR and C504/LDR). The higher the resistance, of the LDR's, the lower the cutoff point of the filter. Thus, the low frequency cutoff tracks the frequency of the received signal, and because the two filter poles are cascaded, the filter slope is 12 dB/octave. When the L.F. FILTER is switched OFF, the Receive Input signal is still routed through the two op-amps that comprise the filter. However, the LED of the LED/LDR unit is disconnected from the Pulse Generator; the dark LED condition holds the LDR's at maximum resistance so that the filter is effectively disabled.

The low frequency cutoff is adjusted with R168. In the filter's most effective range from 20 Hz to approximately 2 kHz, the -3dB point is at a frequency which is approximately equal to the SYNC-signal frequency divided by 20. The maximum loss at center frequency is typically 0.05 dB.

4.3.3 RMS RECTIFIER/LOG CONVERTER.

The L.F. FILTER output is fed to both the Horizontal Axis (X-axis) SYNC switch and to the Vertical Axis (Y-axis) RMS Recti-

fier/Log Converter. (Refer to section 4.5 for a detailed discussion of the Horizontal Axis circuitry.) The RMS Rectifier/Log Converter circuit is a precision module that produces a DC voltage at its output which is logarithmically proportional to the true RMS level of the AC voltage at its input. Thus, the RMS level of the input signal can be displayed in dB. For wide band accuracy, the RMS Rectifier/Log Converter is carefully compensated by external circuitry, including H.F. Neutralization potentiometer R510, Symmetry potentiometer R512, and associated circuitry. Temperature compensation is afforded by a nickel film resistor (R517) in the feedback loop of an output buffer amp (IC501D). To remove any residual AC ripple or high frequency disturbances, the buffered signal is then fed to an active low pass filter (IC303C). The ripple is removed after the RMS conversion because a filter capacitance large enough to accomplish the necessary filtering at the RMS module output (C511) would also slow down the response time of the RMS detector excessively.

4.4 VERTICAL DRIVE CIRCUITRY

The vertical drive circuitry is fed by the filtered DC output of the input circuits, and consists of an output amplifier (IC303B), and a number of switch-selectable feedback resistors which set the sensitivity and scaling factor of the output.

When the INCH-CM switch is in CM position, resistors R401, R403, R405 and R407 are placed in the feedback loop of the amplifier. These resistors correspond to the 4.0 dB, 2.0 dB, 1.0 dB and 0.5 dB VERTICAL RANGE switches. The resistors are wired so that their values are added in series as more sensitivity is selected; the higher series resistance increases the gain of the output amplifier, corresponding to the smaller number of dB per vertical scale unit. Similarly, when the INCH-CM switch is in the INCH position, resistors R402, R404, R406 and R408 (respectively representing the 10.0 dB, 5.0 dB, 2.0 dB and 1.0 dB VERTICAL RANGE switches) are placed in the feedback loop of the amplifier.

Another leg of the INCH-CM switch selects one of two front panel LED indicators that correspond to the chosen units. The output of the vertical drive amplifier is applied to the input of the Y-axis amplifier of the X-Y Recorder (or other display unit) via pins 7 and 8 of the plug-in module's edge connector.

The zero position of the display unit (the middle of the graph paper if the X-Y Recorder is used) is also 0 volts output from IC303B. An input signal level of approximately -24 dB will establish this condition. A decrease in signal level causes a negative output voltage, and an increase causes a positive output voltage. Plus or minus 4 volts is the maximum usable range.

4.5 SYNC PROCESSING CIRCUITRY

4.5.0 EXTERNAL SYNC PREAMPLIFIER.

The EXT SYNC INPUT is designed to accept a wide range of input levels (20 mV to 10 V RMS) without any special adjustments. The incoming signal is fed to a preamplifier which incorporates limiter diodes in its feedback loop. The diodes avoid severe distortion of the output waveform when incoming signal levels are high, since the waveforms that might otherwise occur would contain a large proportion of odd harmonics that could "confuse" the frequency detection circuitry.

4.5.1 SECOND STAGE SYNC PREAMPLIFIER/LIMITER.

The SYNC switch comes after the Sync Input Preamp and selects either that preamp's output or the output of the Receive Section L.F. FILTER (see Section 4.3.3). From the SYNC switch, the signal is routed to a Preamplifier/Limiter consisting of two op-amps (IC301C and IC301B), each set up for 30 dB gain. This dual-stage, high gain preamp is necessary to trigger the SYNC circuitry from low level signals. The limiter, which regulates the signal level to 4 - 5 volts pp, is necessary to prevent "squaring" and harmonics from medium level signals. The Limiter consists of an FET (Q301), a diode (CR303) and related components in the feedback loop which encloses the two op-amps. The output of the Preamplifier/Limiter is routed to two points, the Tracking Bandpass Filter and the Low Level Detector.

4.5.2 LOW LEVEL DETECTOR.

This circuit consists of a positively pre-biased op-amp (IC103D) which senses the negative portion of the signal. The "low Level" LED (LED5) is shunted across the op-amp output, and, since the amp is normally biased off when adequate signal levels are present, the LED is not normally illuminated. If the signal fed to this op-amp is below a safe level for reliable frequency detection, the positive bias will become effective through resistor R109 at the inverting input of IC103D. IC103D's output will go low, thus illuminating the "Low Level" LED. The threshold below which the LED turns on roughly corresponds to a Receive Input signal which is 6 dB below the bottom of the X-Y Recorder's graph paper.

4.5.3 TRACKING BANDPASS FILTER.

(Refer to detailed schematic, Figure 10.) This is a state-variable filter which tunes automatically to the predominant frequency of the input signal. The automatic tuning is achieved

by changing the values of the frequency determining components through varying the light intensity of LED's that affect optically-coupled light-dependent resistors. The circuit is balanced when the bandpass frequency is equal to the input frequency.

4.5.4 SIGNAL SHAPER.

Following the Tracking Bandpass Filter, a very high gain amplifier (IC303A) amplifies the filtered sinewave to create a square wave. The square wave is then fed to the Pulse Generator.

4.6 FREQUENCY DETECTION CIRCUITS

4.6.0 PULSE GENERATOR CIRCUIT.

A Pulse Generator circuit (half of IC101) is adjusted for a pulse width in the order of 30 microseconds. The train of short pulses is then buffered by six paralleled sections of an integrated circuit (IC102).

4.6.1 LOG CONVERTER & DC AMPLIFIER.

The buffered, positive-going spikes are then fed into a Log Converter (IC104D and one transistor of array IC105) where the spikes are translated into a DC voltage which is logarithmically proportional to the frequency of the spikes. A second transistor of the array IC105 is used to couple the log converter's output voltage into a DC amplifier, thus providing temperature compensation, buffering, and additional filtering.

4.6.2 TEMPERATURE CONTROL FOR LOG CONVERTER.

Small temperature changes could markedly affect the Log Converter, so IC105 is held at a constant temperature of about 60°C. The temperature is high enough so that the circuit is immune to all ambient temperature fluctuations below 60°C. The temperature control is accomplished by driving a regulated current through one of the transistors in IC 105 (Pins 9, 10 & 11). That transistor is driven by a differential amplifier (IC104B), which itself is driven by another transistor in IC105 (Pins 6, 7 & 8). The differential amplifier produces enough current in the output transistor so that its temperature increases, and the thermal coupling of all transistors in IC105 causes them to heat to nearly the same temperature. The temperature increase in the input transistor driving the differential amplifier causes that transistor's collector current to change, so that the differential

amplifier then reduces the current flowing through the transistor at its output. The circuit's gain and current flow are arranged so that the temperature stabilizes at approximately 60°C. The log converting transistor, since it is part of the same IC and is thermally coupled to the temperature control transistors, is also held at this temperature. (The case of the IC will be warm, but not so hot that it is dangerous to touch.)

4.6.3 SAMPLE-HOLD & OUTPUT AMPLIFIER CIRCUIT.

The Output Amplifier performs two functions, (1) to invert the voltage so its value increases positively with increasing frequency, and (2) to serve as a Sample and Hold circuit. The Sample & Hold function is switched ON and OFF by an FET (Q102) which gets its trigger voltage from a summing gate output (discussed in more detail in Section 4.7).

4.6.4 1 kHz CAL.

The signal from the Output Amplifier is then routed through a gain adjustment potentiometer (R148), which serves as the 1 kHz Calibration adjustment. The arm of that potentiometer feeds pin 5 of the card edge connector directly, and also feeds Pin 6 through a voltage divider (R149 & R150). The output voltages are 0 to 7.5 V and 0 to 1.05 V respectively. (A 1 volt output drives the Recorder pen across the full width of the graph paper.) The output from pin 6 is designated for driving the X-axis of the X-Y Recorder, and the high level signal at pin 5 is suitable for oscilloscope display.

4.7 PEN LIFT LOGIC

4.7.0 GENERAL.

Various detection and logic circuits cause the pen to lift when the signal is not of usable level, when the frequency is below 20 Hz, when the 2010 is in CAL mode, or when the signal frequency is not well defined. A separate Z-axis output corresponds to the pen lift command, providing blanking for an oscilloscope display. The logic also sends an output to the Sample & Hold circuit so that, if the pen lifts, the pen carriage will remain in the last used X-axis position instead of moving in an uncontrolled fashion. The Pen Lift Drive Amp and the Sample & Hold circuits are triggered by a summing gate consisting of three diodes (CR104, 105 and 106).

4.7.1 LOW LEVEL DETECTOR.

An output from the Low Level Detector (see Section 4.5.2) would cause the summing gate to go low, via CR105, lifting the pen (or blanking the display) when the Sync signal is too low for reliable detection.

4.7.2 MISSING PULSE DETECTOR.

An output from the Missing Pulse Detector also triggers the pen lift (& blanking) circuit and the Sample & Hold circuit, via CR104. The Missing Pulse Detector (1/2 of IC101) uses a transistor (Q101), a resistor (R102) and a capacitor (C102) to sense the time interval between spikes of the pulse generator. At a signal frequency of approximately 18 Hz or less, IC101 generates a negative pulse which is long enough to freeze the Sample & Hold circuit. Thus, this portion of the logic determines the cutoff frequency of the display.

4.7.3 SYMMETRY DETECTOR.

The Symmetry Detector is the last of the three circuits which can trigger the Pen Lift Logic. This circuit can be considered a "smart" circuit in that it separates coherent signals from incoherent signals. An incoherent signal (and also a rapid frequency change) will cause a fast change of DC voltage at the output of the previously described Log Converter (4.6.1). The Symmetry Detector circuit senses, amplifies and rectifies this change into a control voltage which, through diode CR106, affects the Pen Lift Logic. The Symmetry Detector's function can be defeated by switching the PEN switch to DOWN position, which biases the DC amplifier so that the pen will not be lifted (or the display will not be blanked) regardless of signal condition. This is useful when using a test signal such as 1/3-octave filtered pink-noise.

4.7.4 PEN LIFT AMP & BLANKING OUTPUT.

This circuitry consists of an input buffer amplifier (IC303D) and four gates (IC304A, B, C & D). Output transistor Q102 must conduct for the pen to drop onto the graph paper. A "lift" command removes the bias voltage at Q102's base, the transistor turns off, and the pen lifts off the paper. (The electronic circuit which drives the pen solenoid is part of the X-Y Recorder, and it connects to pin 4 of the card edge connector.) Simultaneously, a "blank" command appears at two pins of the card edge connector; the voltage at pin 2 changes from low to high level, and at pin 3 in the opposite direction.

4.8 POWER SUPPLY

The power supply consists of two voltage regulators (VR101 & 102), plus related components on the X-Channel board. The incoming +16 volts (pin 10) and -16 volts (pin 9) from the card edge connector are well filtered and regulated to an output of ± 10 volts. (Pins 4, 7 and 8 are paralleled as power supply common). If the X-Y Recorder is not used as a display unit, then ± 16 to ± 18 V DC must be supplied to these pins on the X-Channel circuit board from a suitable source.

SECTION V

MAINTENANCE

5.1 GENERAL

The Model 2010 Plug-In Module is a ruggedly constructed, all solid-state unit, and is mechanically protected by its own housing. As such, the Model 2010 should provide years of trouble free use with normal care. All parts are conservatively rated for their application, and workmanship meets the rigid standards you have learned to expect in UREI products.

NO SPECIAL PREVENTIVE MAINTENANCE IS REQUIRED.

5.2 REPAIRS AND WARRANTY

The instrument is factory warranted against defects in material and workmanship for one year after initial purchase. This Warranty must be activated at the time of purchase by returning the registry portion of the Warranty Card to the factory. Should a malfunction ever occur, the dealer from whom the unit was purchased will be glad to handle return for factory repair; alternately, for prompt service, ship the unit prepaid freight directly to the factory. Be sure that it is well packed in a sturdy carton, with shock-absorbing material such as foam rubber, styrofoam pellets, or "bubble-pack" completely filling the remaining space. Particular attention should be paid to protecting the protruding parts. Include a note describing the malfunction, and instructions for return. We will pay one-way return shipping costs on any in-warranty repair.

NOTE: If the malfunction clearly indicates that the problem is due to a defect in the Plug-In Module, and not in the Recorder, it is sufficient to return only the module. In all other cases, or when in doubt, the complete system (that is, the Model 200 X-Y Recorder and the Model 2010 Module) should be returned to avoid delay in service.

5.3 PERFORMANCE CHECKS

Every time the system is calibrated according to Sections 3.2 through 3.4, a complete performance check has been carried out. All necessary adjustments are accessible through the front panel.

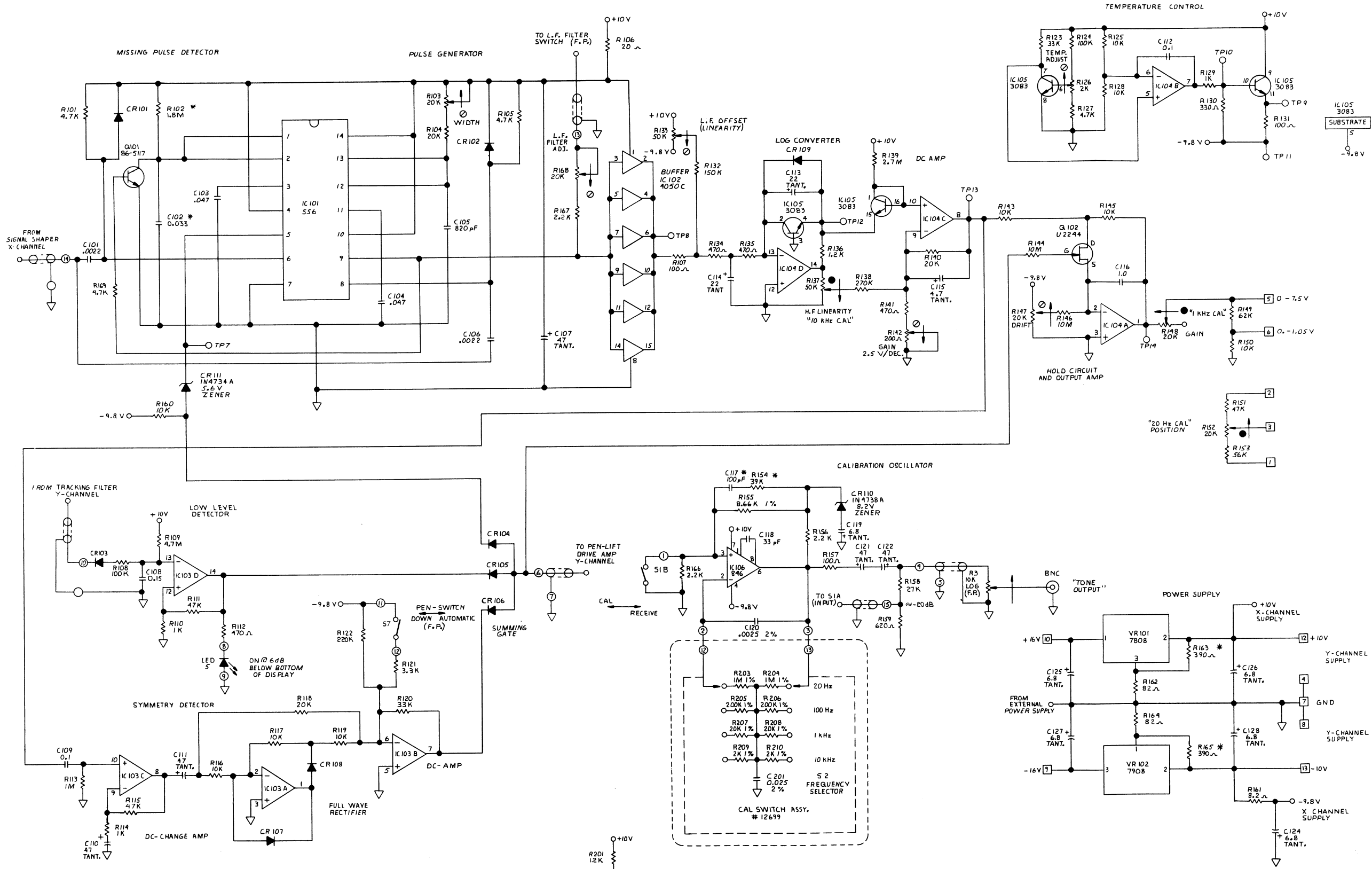
Additional multi-turn adjustments are made inside the module. They are factory calibrated and should not be changed in the field since specialized test instruments and procedures are required.

5.4 X-Y RECORDER MAINTENANCE

It has been our experience that the H.P. main frame will perform without trouble for a long period of time. It is suggested, though, that the maintenance described in the H.P. Operating Manual <Section V> should be performed when necessary.

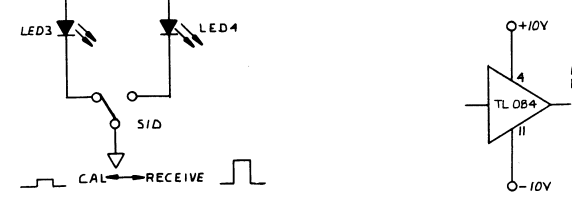
The Autogrip table should be cleaned regularly to assure adhesion of the graph paper <H.P. Section 5-9, paragraph d>.

After the first few weeks of use, the operator may notice that the motor which moves the pen along the Y-axis will not stall when the carriage is driven off the paper. This suggests that the string tension requires adjustment <H.P. Section 5-60, figure 5-6>.



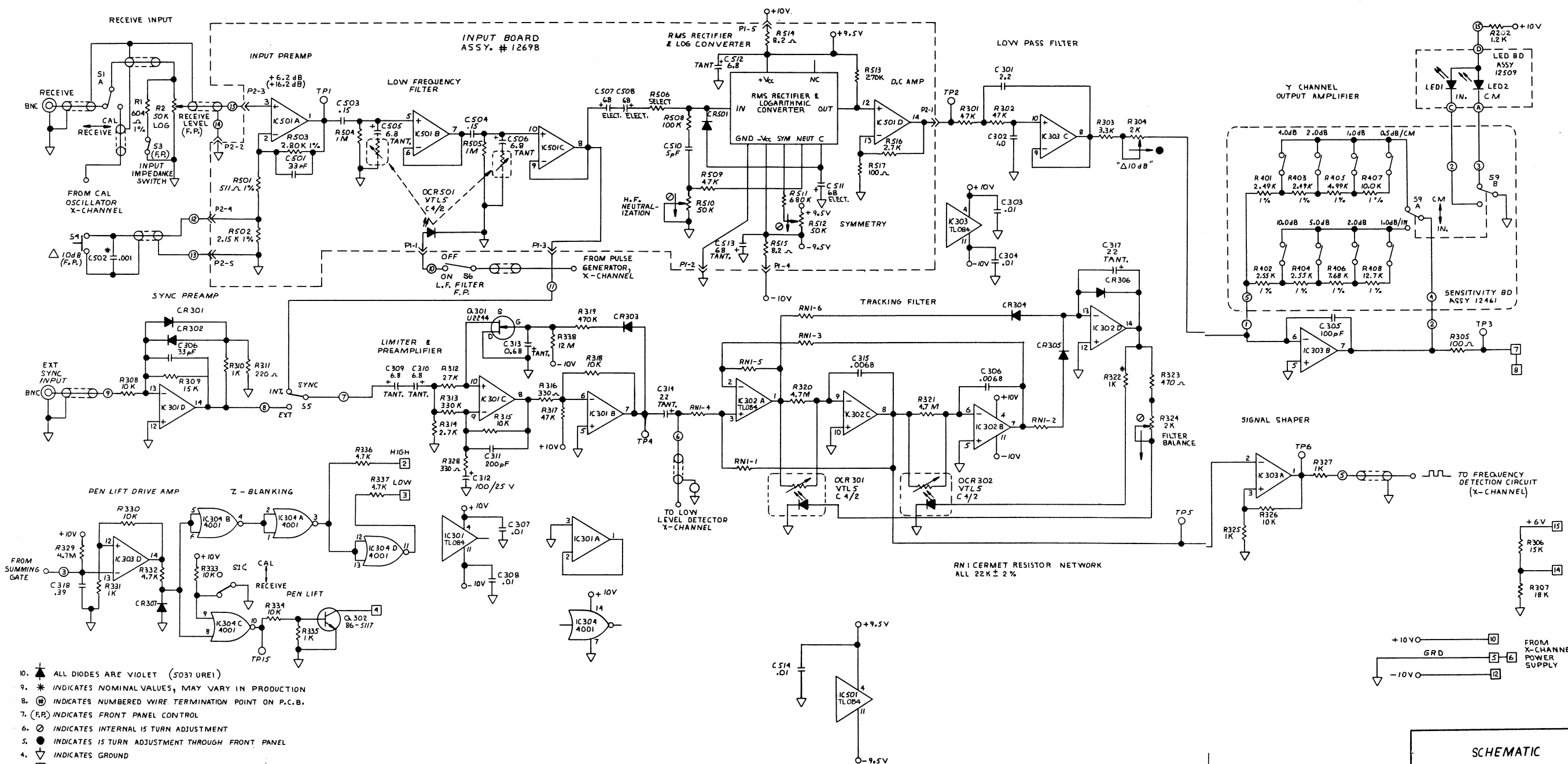
- 10. ALL DIODES ARE VIOLET (5037 URE1)
- 9. * INDICATES NOMINAL VALUES, MAY VARY IN PRODUCTION
- 8. INDICATES NUMBERED WIRED TERMINATION POINT ON P.C.B.
- 7. (F.P.) INDICATES FRONT PANEL CONTROL
- 6. INDICATES INTERNAL 15-TURN ADJUSTMENT
- 5. INDICATES 15-TURN ADJUSTMENT THROUGH FRONT PANEL
- 4. INDICATES GROUND
- 3. INDICATES CARD EDGE CONNECTION NUMBER
- 2. CAPACITOR VALUES ARE IN MKROFARADS
- 1. RESISTOR VALUES ARE IN OHMS ± 5% 1/2W

NOTES: UNLESS OTHERWISE SPECIFIED



REV. E	PER. EDO-2010-012	6-9-79
REV. D	PER. EDO 0203 4-13-78-RPM	
REV. C	PER. EDO 0190 10-24-77 R.P.M.	
REV. B	PER. EDO 0088 10-19-77 R.P.M.	
REV. A	PER. EDO 0187 9-29-77 R.P.M.	

X-CHANNEL SCHEMATIC		
SIZE	MODEL NO.	DRAWING NO.
R	2010	12750 E
DATE	6-17-77	DR. BY: R.P.M. SHEET OF



- 10. \blacktriangle ALL DIODES ARE VIOLET (5031 URE1)
 - 9. * INDICATES NOMINAL VALUES, MAY VARY IN PRODUCTION
 - 8. $\textcircled{8}$ INDICATES NUMBERED WIRE TERMINATION POINT ON P.C.B.
 - 7. (F.P.) INDICATES FRONT PANEL CONTROL
 - 6. $\textcircled{6}$ INDICATES INTERNAL 15 TURN ADJUSTMENT
 - 5. \bullet INDICATES 15 TURN ADJUSTMENT THROUGH FRONT PANEL
 - 4. ∇ INDICATES GROUND
 - 3. $\#$ INDICATES CARD EDGE CONNECTION NUMBER
 - 2. CAPACITOR VALUES ARE IN MICROFARADS
 - 1. RESISTOR VALUES ARE IN OHMS $\pm 5\%$ 1/2 W
- NOTES: UNLESS OTHERWISE SPECIFIED

REV. F PER ECO-2010-013 AND ECO-2010-014	1-3-78 R.P.M.
4-A-79 B EFFECTIVE SER# 226	1-3-78 R.P.M.
REV. E PER ECO-2010-011	6-19-78 BOM
REV. D PER ECO-2010-009	4-12-78 R.P.M.
REV. C PER ED 0203	11-24-77 R.P.M.
REV. B PER ED 0190	9-29-77 R.P.M.
REV. A PER ED 0187	9-29-77 R.P.M.

SCHEMATIC Y-CHANNEL		
SIZE	MODEL NO.	DRAWING NO.
R	2010	12741 F
DATE: 6-9-77	DR: BY: R.P.M.	SHEET OF